CHARTING MEMORY MANAGEMENT

September/October 1991 Volume 9.5

Programmer's Journal

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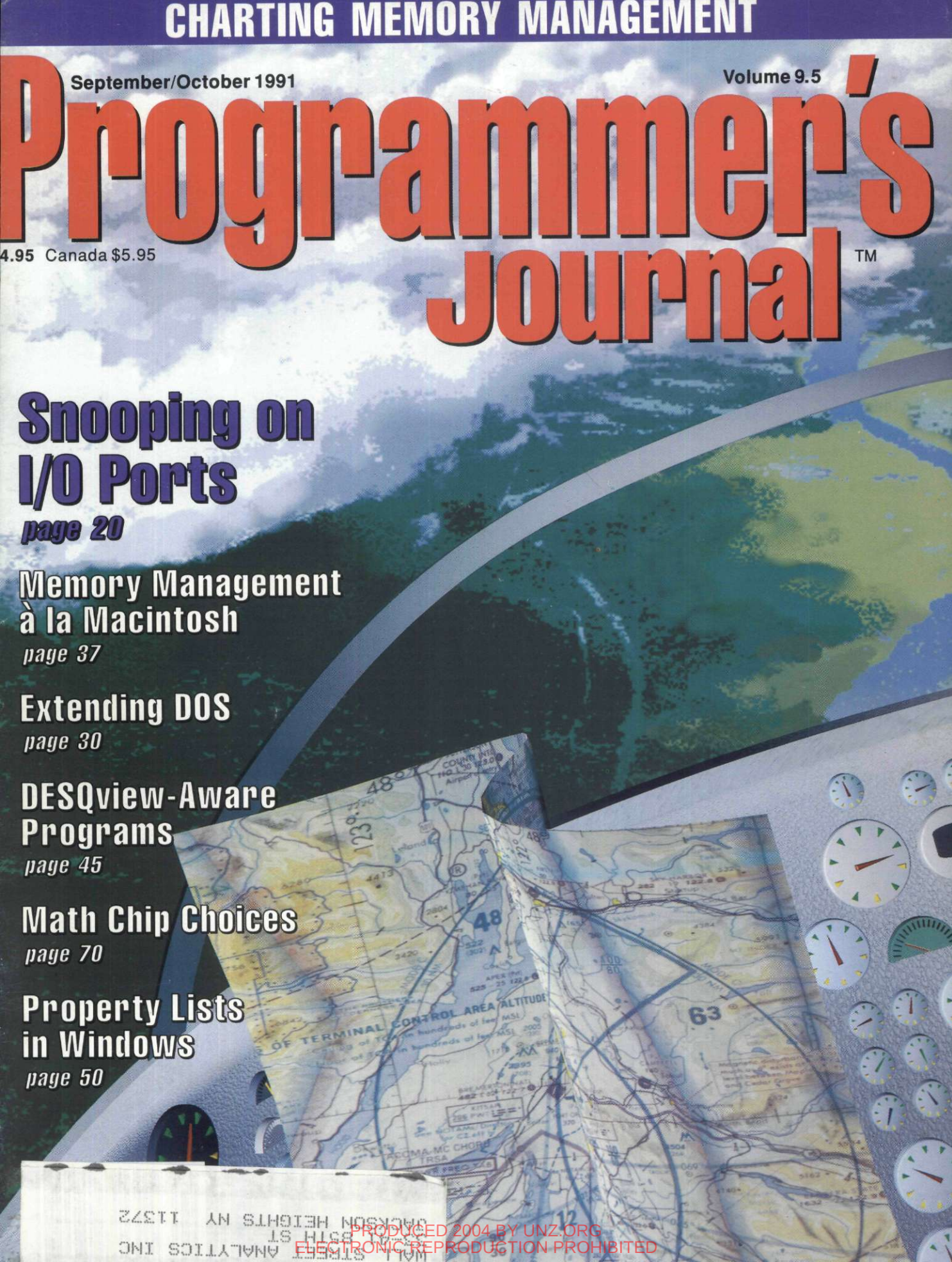

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Recycle

Everyone wants more productivity out of their computers.

But not everybody is willing to spend a fortune to get it. That's why Quarterdeck productivity software is outselling everyone else's—including Microsoft's.

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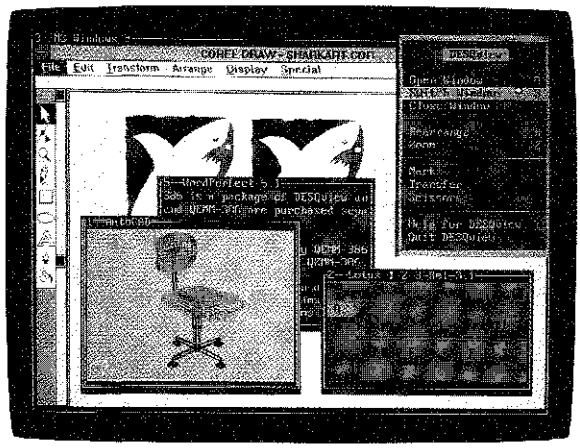

Over 1,000,000 users multitask their programs with DESQview.

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QEMM 386 is included with DESQview 386 to create the optimum operating environment for productivity oriented users of 386, 386SX and i486 PCs.

QEMM 50/60 is designed to work in IBM® PS/2™ Model 50 and 60 PCs with specific IBM adapter boards.

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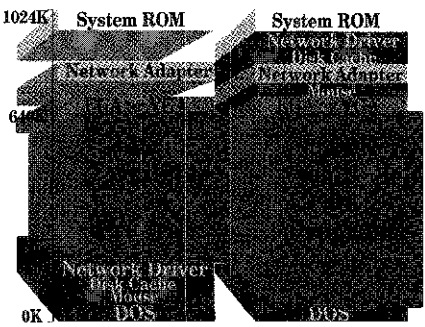

Before *After*

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PC WORLD BEST BUY

PC MAGAZINE EDITORS' CHOICE

PC MAGAZINE EDITORS' CHOICE

PC Computing MVP MOST VALUABLE PRODUCT 1990

PC TECH Professional Solutions Award 1989 Best Operating Environment

1989 BYTE AWARDS OF EXCELLENCE

These are some of DESQview's most recent awards

QEMM 386 PC WEEK PRODUCT EVALUATION SCORE 8.6

INFO WORLD BEST IBM ITS CLASS Dec. 18, 1989

INFO WORLD TOP 100 1989

1989 BYTE AWARDS OF EXCELLENCE

PC Computing MVP MOST VALUABLE PRODUCT 1990

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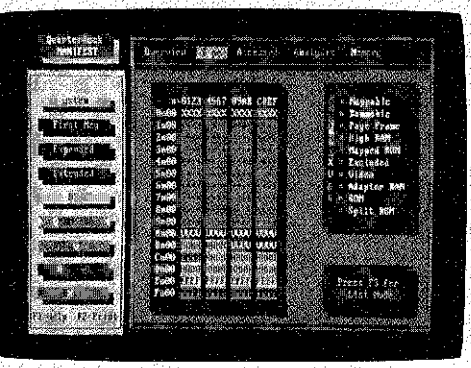
your PC

Manifest Gives You In-Depth Knowledge of Your PC



Our newest utility is Quarterdeck Manifest, the best way to discover everything you ever wanted to know about your PC. Manifest shows you around 'under the hood', pointing out how memory is used, comparing memory speeds, and indicating how you can gain more room for your programs to work.

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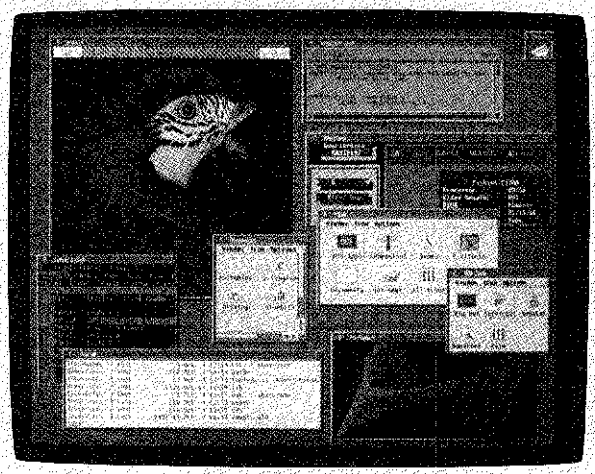
A Glimpse of the Future: DESQview/X

We're also looking ahead to the next wave of computer system development: enterprise computing. Our new



DESQview/X allows different computers with different operating systems to work together. Using the advanced X-windows environment, it lets users run programs on remote computers and watch them run in their PCs' windows. DESQview/X will be available later this year.

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- ✓ No logic errors to debug!
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The ***COBRA*** System is easy to learn and use. With the examples in the manual and online HELP file, you can generate your first program in less than one hour from opening the package.

Here are the only statements required to generate a complete COBOL program - an internally sorted, control-break totals report:

```
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REPORT TOTALS
SELECT EMPLOYEE-NBR, EMPLOYEE-LAST-NAME, EMPLOYEE-FIRSTNAME,
       ADDRESS,      THIS-PER-EARNINGS,  YEAR-TO-DATE-EARNINGS
FROM EARNINGS-FILE
ORDER BY PLANT-CODE, DEPT-NBR, EMPLOYEE-NBR
GROUP BY PLANT-CODE, DEPT-NBR
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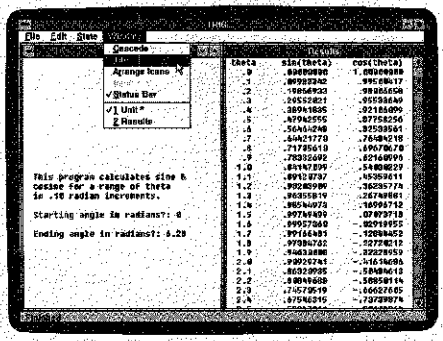
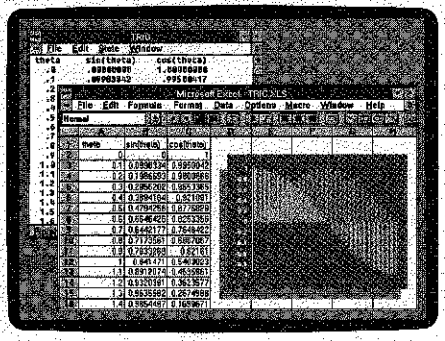
MICROSOFT SOFTWARE DEVELOPMENT TOOLS

Windows helps FORTRAN users create bigger apps.



The Microsoft Windows graphical environment lets you have multiple windows in your FORTRAN applications. This means that you can resize and scroll input and output displays to view data...



...and to analyze data, simply cut and paste your FORTRAN output into programs such as Microsoft Excel for Windows and you can view it instantly in graphical form.

With the new Microsoft® FORTRAN Professional Development System version 5.1, your existing code taps into the power of the Microsoft Windows™ graphical environment. FORTRAN 5.1's new QuickWin library lets you develop 16-bit apps that access greater memory than ever before – breaking the 640K barrier on 286 and 386 machines.

You can use the FORTRAN QuickWin library to take advantage of multiple I/O windows, multitasking, and cut and paste. Or write FORTRAN routines called from mixed-language Windows apps. And FORTRAN 5.1 has Programmer's WorkBench, with a new CodeView® debugger and Source Browser.

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Key Features

- Create Windows .DLLs in FORTRAN using new or existing code.
- QuickWin Features:
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- CodeView debugger supports DOS*, Windows-based and OS/2® applications.
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- *Use the new /MW option with the FL command to invoke the QuickWin library. For example: "FL/MW MYAPP.FOR" is all it takes to make MYAPP a Windows-based program.*
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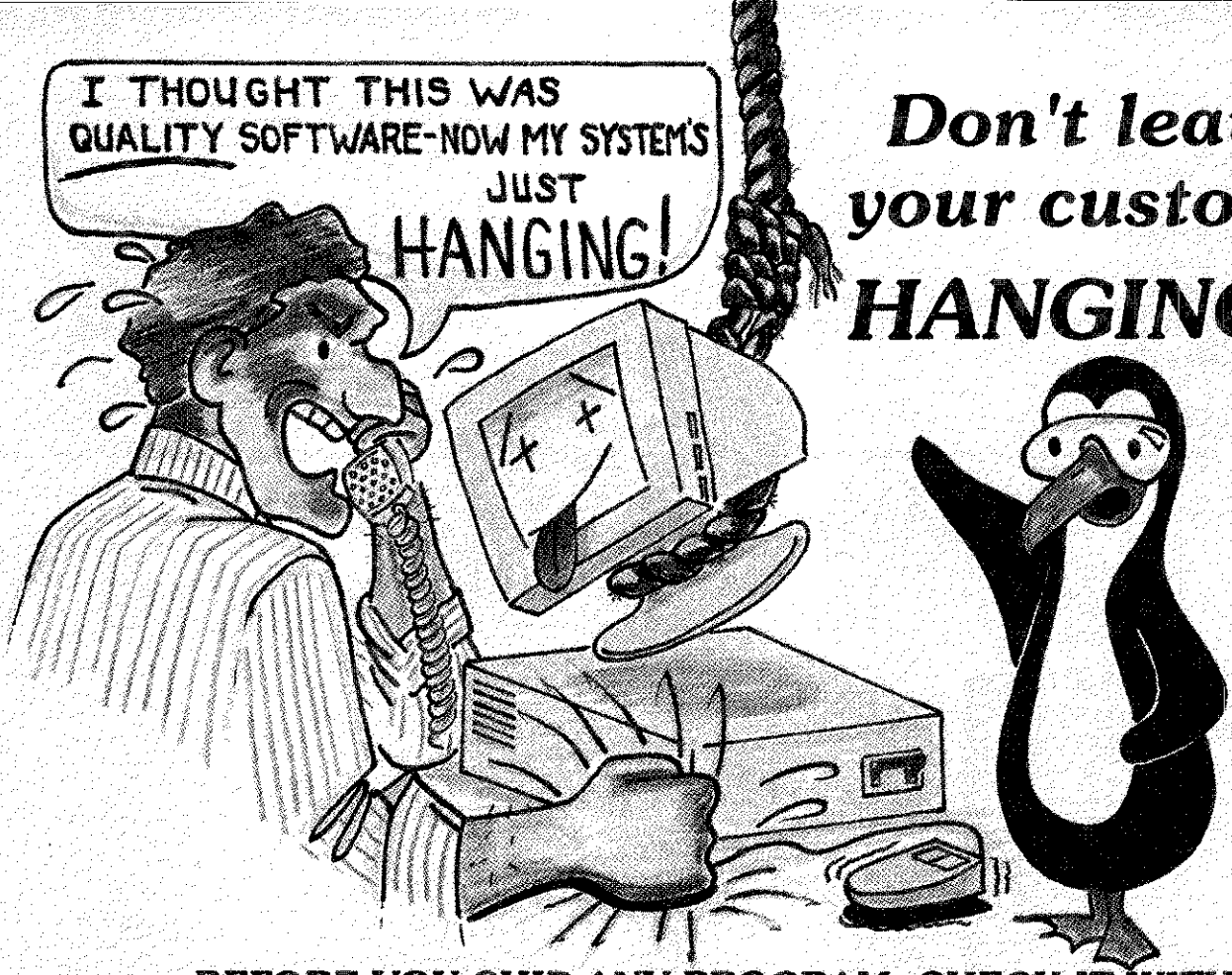

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WINNER PC MAGAZINE BEST OF 1990

JANUARY 15, 1991 PAGE 168

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Programmer's Journal™

September/October 1991 Volume 9.5

You don't have to fly blind through the ever-expanding terrain of operating systems. Use this issue to chart a smooth flight path to optimal memory management.

Happy landings!

Cover Art: Digital Artworks

FEATURES

SYSTEMS **20** **EAVESDROPPING ON I/O** *By Rick Knoblaugh*
Your mother taught you it wasn't nice to eavesdrop, but with Rick's code and the virtual-8086 mode of the 386, you won't be able to resist checking out what your I/O ports are up to.

SYSTEMS **30** **DOS EXTENDERS** *By M. Steven Baker*
DOS extenders continue to open up new horizons for the 286 and 386. The hot new phrase is DPMI compatibility, which allows extended DOS apps to run under Windows 3. Steve weaves through the maze of new products available for stretching the limits of DOS.

SYSTEMS **37** **MANAGING MEMORY** *By Brett Glass*
The early Macintosh computers were born in an age of limited memory, so Apple's system designers incorporated a sophisticated memory-management system. Brett looks at the strengths and limitations of this Mac-style, handle-based memory scheme.

SYSTEMS **45** **DESQVIEW-AWARE PROGRAMS** *By Murray L. Lesser*
Don't turn off Murray's tailor-made ALARM program—it might help keep track of your schedule and free you from watching the clock while under the spell of the computer muse. Along the way, learn how to take advantage of DESQview's multitasking capabilities by mixing assembly language with BASIC.

WINDOWS **50** **WINDOWS PROPERTY LISTS** *By William S. Hall*
DOS isn't the only operating system that fences you in. Bill shows how to overcome Windows memory-management problems with the right properties in hand.

GRAPHICS **61** **ICON POWER** *By Peder Jungck*
Walk like an encryption and look like a wizard—Peder shows how to use VGA write mode 1 to draw icons with lightning speed. Avoid the bus bottleneck—take a magic carpet ride instead.

NUMERICS **70** **DIVIDE AND CONQUER** *By Mark J. Barrenechea*
Mark evaluates floating-point coprocessor options for the 80386 and 80486, comparing the performance of I/O and memory-mapped math chips. Although the trend in the nineties is toward tightly integrating the floating-point and integer execution units, his test results provide some surprises.

C **76** **WINDOW LAYERS** *By Allen Holub*
In this installment of his windowing system, Allen makes it clear that every window has its layers. Learn to see your way through the viewport and text buffer to the underlying file.

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EDITOR'S NOTE

Well pardners, it's time again for my written ramblings. You may have guessed that my previous training had no connection with publishing. I did write a musical, "Florida Cowboys," in fifth grade, but the theater circuit never picked it up. Then I was going to be a "creative scientist." An architect and engineer by training, I stumbled into the computer business. A few years back I started editing and writing, and I've been observing the industry from this vantage point ever since.

The time seems ripe for exploring systems programming on the PC. Microsoft has released MS-DOS 5, a long-overdue improvement over its half-broken predecessors. One assumes it wasn't by chance that Microsoft's DOS 5 arrived before DR-DOS 5 from Digital Research (now owned by Novell) could catch the wave.

The split between Microsoft and IBM is getting lots of attention. Any day now we'll have Windows 3.1 bucking out of the bronco pen, sporting pen-based computing, multimedia extensions, and TrueType fonts. Meanwhile, back at the Boca Raton ranch, IBM has promised OS/2 2.0 by year's end. Their OS/2 Developer's Assistance Program includes free beta product to both small and large developers, OS/2 porting technical support, and hardware loans (PS/2s, we presume).

This new OS/2 version looks promising. It has a DOS compatibility box that works, and support for DPMI and the Windows 3 API is forthcoming. Unfortunately, many developers got burned believing Big Blue's previous promises for OS 1.2. We'll soon know whether IBM can deliver the goods and go head-to-head against Microsoft's DOS and Windows. The skirmish should last until Windows 4 (WIN32) and DOS 6 are released. Because version 2 will support the Windows 3 API and DPMI, developers can program for Windows or a DOS extender and still run under the new IBM OS without ever writing OS/2 or Presentation Manager code. This means that DOS and Windows remain safer bets for many developers.

NEW DOS EXTENDERS RIDE INTO TOWN

Inertia is a powerful force, which accounts for the incredible staying power of DOS. Before we move to the 586, software developers should take advantage of the 386. So DOS extenders are turning up in more and more products. Most DOS extenders will soon be updated to support DPMI. Phar Lap was first out of the gate with new 286 and 386 releases, soon to be followed by Rational and Ergo. These new versions allow you to build applications that run under Windows as DOS apps. Several 386 compiler vendors (Watcom, MetaWare, and MicroWay) will be offering products to support a 32-bit Windows API from the 386 protected mode (no small feat).

Intel's C Code Builder is bundled with a DPMI-compatible version of the IGC DOS extender. I'd keep an eye on Silicon Valley Software (SVS); they're including the same Intel (IGC) DOS extender with their C, Fortran, and Pascal language products, and their prices are very attractive. Both offer free runtimes as well.

System 7 will keep Apple developers and users busy for a while. The 386 Unix market is now shipping System V Release 4.0, which merges the BSD variant with the AT&T strain. Some vendors toss in X Window and either the Open Look or OSF Motif GUI interfaces. Fortunately, the hardware is keeping ahead of the gluttonous software: if you want Unix 4, expect 80 disks or a 120MB tape cartridge. Sun discounts CD-ROM readers so that they can ship all their OSes on a single CD.

THE CORPORATE GIANTS AND THE UPSTARTS

The hottest news these days is that the big guys are cutting deals with each other like crazy: Apple and IBM set up a partnership to develop the OS of the future, IBM and Wang sell mutual products, Borland buys Ashton-Tate to become number three in the U.S. software business (just behind Lotus), Novell buys Digital Research. The prevailing assumption is that there is safety in numbers (of dollars and shares)—the bigger they get, the less often they fall.

But as the market expands, new crevices form in which small companies can get a foothold. The Windows developer tool market is a prime example of this kind of opportunity. Who knows what fertile ground these OSes will provide, or what new products will rise up from them?

Steven Baker

Programmer's Journal

Editor
M. Steven Baker

Managing Editor
Cecelia Hagen

Associate Editor
M. Elizabeth Hardinger

Contributing Editors
Michael Abrash, Brett Glass, Frank D. Greco, John Otken, Tom Swan

Founder
Greg Estes

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Elizabeth Oakley

Advertising Manager
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LETTERS

WE ALL LAUGHED

Is your correspondent Mr. Stanislav a humorist, or what? In his letter (*PJ* 9.4) he states that he writes about 2000 lines of code a day. If each line is 20 characters, he types about 40,000 characters a day, or about 5000 characters per hour. This equals approximately 16 words per minute, which is about one-third the speed of an average typist entering directly from copy.

Of course, that's probably an easy program of 40,000 or 50,000 lines, such as a complete general ledger program. For more difficult stuff, like a multitasking operating system, Mr. Stanislav would probably slow down. With such programming speed available, it's surprising that the rest of us low-productivity programmers aren't out on the streets.

Could Mr. Stanislav be enticed to write an article for *PJ?* Suggested titles: "A StarWars drop-in module" (available on 256,000 CD-ROMs); "KEYPRO: Make your 'A' key write structured modules"; or "The meeting that prevented me from writing OS/2 4." Naturally, I have hidden this issue from my boss—I don't want to be replaced by Mr. Stanislav working during his coffee break.

Seriously, we need humor in our dull, drab programming lives, and I'm glad that *PJ* has made our programming staff fall all over themselves laughing.

JP Harrison
Hood River, OR

VEXED BY HEX

The "Hexadecimal number conversion" sidebar in Mark Barrenechea's article (*PJ* 9.3) explaining the conversion of the hex value 4CEB79A3 to single-precision floating point committed two egregious errors. The result was shown as 493827168.0; the correct result is 123456792.0.

The first error came from the computation of the unbiased exponent: the bias is 127, not 128. Therefore, the unbiased exponent is 26, not 25.

The second error came from the shift of the normalized significand to the finalized binary form. The radix point (not the "significand," as stated) was shifted right 28 places—not 26, or even 25.

The hex representation of the number 493827168.0 is 4DEB79A3, which differs in one nibble from that given in

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HA HA HA HA HA HA HA HA HA HA
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HA HA HA
HA HA HA

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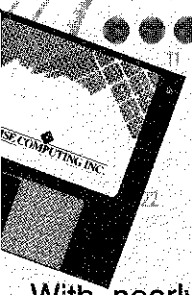

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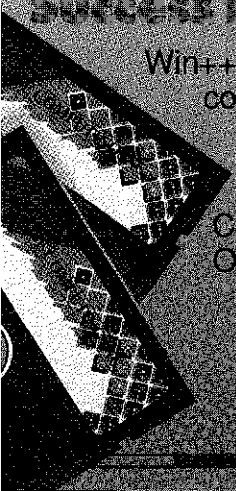

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TQM: The new Beltway buzzword

By Paul A. Barkley

When the massive Desert Storm victory parade marched through D.C. in June, I didn't see a TQM float on the Mall, but there might as well have been one. You're going to hear more and more stories from TQM seminar leaders about how the war was won because this or that small supplier ran their businesses using TQM. You may not hear TQM and Patriot missile in the same sentence, but you're no doubt going to hear about TQM and the parts suppliers for those missiles.

TQM stands for Total Quality Management, and the federal government is going after it in a big way. It starts with a few government managers who come back from a TQM seminar with some ideas. At first, they encounter resistance, particularly from the long-term bureaucrats, but pretty soon a few managers here and there have tried some of the ideas and found some success. The higher-up managers get the TQM religion, send their subordinates off to classes, and so it goes. The upshot of all this is that it's no longer enough to submit the lowest bid. Firms that want federal contracts are expected to deliver high-quality goods and services as well. That's a tall order.

Meanwhile, consulting and contracting firms are doing business as usual: finding more and more ways to cut costs and fighting the "o" word ("overhead"). Eventually, it will become obvious that some sort of attention to quality is necessary to keep the clients happy. The *Challenger* disaster was an expensive lesson in the importance of quality versus the lure of cutting corners.

Maybe "business as usual" is about to change. Maybe one day the government will start requiring successful bidders to have a TQM philosophy in place. Until then, if TQM works half as well as people say it does, it will be a real competitive advantage.

ILLUSTRATION BY JIM CARPENTER

WHAT IS TQM?

I don't pretend to be a TQM expert. It has too many aspects to assimilate at one time, and a disturbing amount of the TQM interpretation seems contradictory—sort of like a Kahlil Gibran poem. Gibran would explain what a tree was like by saying that a tree was sort of like the daytime, and then again sort of like the nighttime. By the time he finished, you didn't have the vaguest idea what a tree was like, but you knew you wanted to strangle him. TQM is a lot like that.

TQM is a philosophy of doing business. An American named W. Edwards Deming dreamed up TQM 30 years ago, but the Japanese were the first to see its potential. It's a way of looking at the job, not just a few isolated principles to put in place. If you embrace one of the martial arts, it is said, you'll find a calm center and learn to deal with stress. (Of course, you'll also be able to break bricks with the side of your hand.) Similarly, TQM will have you looking differently at the way you work, searching for new ways to do things that you once took for granted. TQM isn't accomplished any faster than a black belt is; changes in your organization will take time.

CONTINUOUS IMPROVEMENT

To me the most important principle of TQM is continuous improvement. You must never be satisfied with the status quo, because you can always increase the quality of your product or service.

TQM's opposite is the "If it ain't broke, don't fix it" approach. One company I worked for was developing Clipper programs on a large contract. Some of the people had been working on this contract for many years, so there was a substantial contract history and an accompanying attitude of inertia.

I started talking about the need to develop a set of reusable modules with increased usefulness. The work, organized by end-user program offices, was fragmented, so that the only people who could maintain the systems were those in the same small office team. Yet some of the best coders were perfectly content with what they were doing. They were turning out "pretty good" systems. The clients weren't complaining, and the systems functioned decently. They had been developed fairly efficiently because the coders, like all experienced coders, kept improving their modules with each new system, starting as much as possible with the old modules and then adding a little tweak here or there.

What the coders didn't realize was that no one had an *overall* best system. When we began to discuss each module, ideas started to flow. For years, I've written systems without a backup and restore utility built in; I let my users handle this with outside methods. Other coders were nicer to their users: they had simple routines to copy files, assuming that they could fit on a single floppy. One programmer had a routine to figure out how much room there was on the floppy. It would then write out DBF records one at a time until the disk was filled. Records would continue writing on the next disk, thus eliminating the problem of handling multiple

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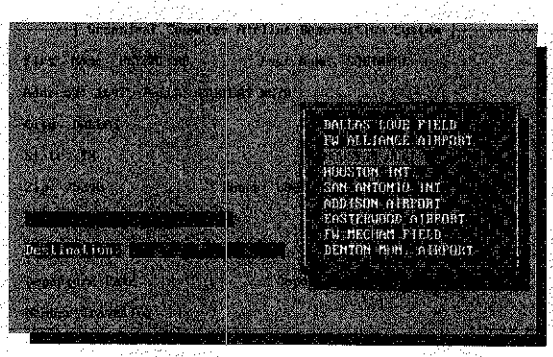

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disks (but only if you were backing up DBF files).

Another programmer had a way to break any file across disks. Someone else had written a compression routine in assembly language that was linked to his Clipper code, but he didn't break files across disks. Many other ideas flowed from this, such as setting flags to determine backup frequency and warning the user periodically in the initialization module that backups were overdue.

The result, module by module, was an evolving set of specifications, even though people had been content before we started. When we finished, the users were happier with their systems.

The Japanese have a word for this process of continuous improvement. They call it *kaizen*. Even if you confuse the cry of suicidal warriors (*banzai*) with the name for dwarfed trees (*bonsai*), you ought to remember *kaizen*. What can you do to increase the quality of the systems that you write? Are your clients really happy, or is some firm going to woo them away with a better product?

INCH BY INCH

Measurement is another important concept in TQM. Without measurement, you can't tell whether you are improving. Don't be too quick to dismiss the feasibility of measuring the improvement of *your* particular business. Even though TQM did evolve in a manufacturing environment—where you can count the output, the number of defects, and the mean time between failures—the principle of measurement can be applied to any kind of work.

Let's say we run a hot line on our contract. Users call in and either we fix their problems over the phone or we dispatch other support teams to clean up the mess. An obvious measurement in this case would be how long it takes to close a call. If we find ways to improve our services—by getting answers to users faster, by dispatching teams from a more appropriately located organization, or by some other process—then we can expect the measure of response time to decrease. If it takes an average of four hours to close a call now and we cut that down to 17 minutes, then we can pat ourselves on the back for a tremendous improvement. We might eventually get that number down a few more minutes, but eventually we will hit a brick wall (and wish we had enrolled in that martial arts training instead). We'll have to look for other ways to improve, such as measuring the number of times we actually gave the *right* answers, or something revolutionary like that. One thing at a time.

As a practical matter, I think measurement may be one of those things that requires some substantial outside input. If you can't think of anything to measure in your own work, talk to your most vocal critic. Or better yet, go find your customer. I'm sure they'll come up with some dandy measures.

WE'RE ALL IN THIS TOGETHER

TQM bridges organization lines, and it even extends up and down the channels to your suppliers and your customers. If you're trying to make things work better, your customers must be a part of that process. How many times have you remarked that building custom systems would be a great business if it weren't for the users? Similarly, your work can't get done if your suppliers don't cooperate. (Suppliers can be outside vendors or internal suppliers of services, such as accounting or payroll.)

Now look at it from the point of view of the government (or whoever your client is): as *their* supplier, you may be part of *their* problem! If you can solve some of their problems by doing your job better, then you're going to have happier clients. What a concept.

I recall a similar principle from the world of MBAs—specifically, the retailing arena. If you sell hardware and software, then you're part of a retail channel that includes your software wholesalers and the publishers who supply them. You're at the end of the channel, supplying the customers. Similarly, you're at the end of a hardware channel that goes back to the manufacturer. In fact, you're at the end of multiple channels.

There are many other channels around, and they compete with yours. Your software wholesaler probably sells to other shops (creating competing channels), and you probably buy from several software wholesalers. It's in your best interest to work with the other members of your channel to deliver the goods better than any other channel. That might mean having software publishers come to your store to train your people, so that you can offer better service than the gas station on the corner that sells corn chips and spreadsheets. The wholesaler may have training arrangements, too. An enlightened publisher will realize that if the customers from the chain of gas stations comprise 1 percent of their sales and 90 percent of their support calls, then maybe there's a better way to do business.

The point is, if you don't work both with your suppliers and with your customers to find out what you can do better, someone in another channel entirely will come along and deliver a better product or service. I hate it when that happens.

TURNING THE CHANNEL

If you're in the consulting business and you use third-party libraries, consider offering the manufacturer some suggestions of how they could improve their product. Smart publishers are delighted to have these suggestions; they want to work with their customers, because they know that their success depends on the success of the consultants using their products. For example, if you do Clipper work, you're in a channel partnership with Nantucket and the third-party publishers. This channel is competing with mainframe, mini, and other micro channels such as the Paradox consultants. Join a local Clipper developers' group. Although you may think of the other members as your competitors, all of you are competing against HP VAR channels, Rbase channels, and others.

Help your channel members, all the way up to Nantucket. Nantucket, to continue the example, is the quintessential nonchannel player. They nominally support the user and developer groups, but the groups don't feel warm and cuddly about Nantucket because Nantucket doesn't understand their role as part of a larger channel. If they're not careful, the Fox channel is going to blow them away.

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A TQM BY ANY OTHER NAME

One of the best things about TQM is that you can play around with the concepts, putting them together in different combinations and even inventing new acronyms. In a discussion group the other day, a colleague came up with the acronym "RAT" to illustrate three related ideas.

The *R* stands for responsibility. Each person has to take responsibility for the quality of their work when you buy into TQM. You can't just shrug something off as "not my job." You can see why TQM needs to become an attitude to be effective; responsibility is easy to talk about, but getting your team to buy into it is more difficult.

The *A* stands for authority. If you take responsibility for your work (or worse, if you're held accountable against your will) but you don't have any control, you'll quickly go mad. TQM suggests pushing the authority down as far as it can go. This would mean that each worker on the assembly line would have the authority to reject a part if it didn't meet standards. Each worker has the authority to back up the responsibility that they're asked to take on.

Most people don't know what they're doing half the time; before they get it figured out, someone transfers them or promotes them to a new job.

As another example, consider how raises are handled in your company. Traditionally, lower-level managers may suggest a percentage, but high-level managers make the decision. TQM suggests that the top-level management push this process down: set the raise pool at a high level, for example, and then tell the next management level down that they have *x* number of dollars to hand out. This process can go on until the people handing out the money are the direct supervisors of the people getting the raises.

The *T* stands for training. You wouldn't ask someone to dig a ditch without a shovel, so why would you take someone who was hired to do office automation support, give them a manual, and ask them to develop systems? Don't underestimate the value of training. Most people don't know what they're doing half the time; before they get it figured out, someone transfers them or promotes them to a new job. I've seen many programmers who can't write decent code, but they can screw up in five languages. Their COBOL is cobbled, their Oracle orbicular, their

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dBASE defiled, their Paradox paranormal, and their Fortran is all forked up. What they need is time out to learn how to code well in one language, how to structure code, how to debug it, how to document it, and how to prevent maintenance nightmares for other people.

FULL OF SURPRISES

I was cynical about whether TQM would work in a traditional corporate environment. First, I knew that the process was probably client-driven: the government wants it and wants to see the contractors embrace it, so therefore we want it. QED.

Second, for every principle of TQM that I've heard espoused, I can think of dozens of high-level managers who embody the antithesis. You have to figure that there's going to be some powerful opposition to TQM from those at the top, which is precisely where support for it has to come from.

But in spite of the initial cynicism and the resistance of inertia, it looks as if TQM is starting to work. The folks who hang out above the cloud cover on the top floor keep coming up with new ideas, such as salary pools. Naturally, my peers and I think these ideas are great, and we think we've been practicing most of them all along. But when TQM gets to the level below us, we may be in for a rude awakening. After all, the top-level managers were pretty surprised at some of the problems that *we* brought up: they thought everything had been working just fine.

In spite of the initial cynicism and the resistance of inertia, it looks as if TQM is starting to work.

GETTING BETTER ALL THE TIME

Three things seem to come out of TQM. The first thing has nothing to do with the merits of the concept. If you made up any acronym, say PAB, and then got everyone together, starting at the top, to talk about problems and how they could be solved, you would be bound to see improvement. Experimental psychology shows that almost anything you do in a positive way will improve morale and output. I know PAB can make a big difference in your company; now I'm looking for a foreign country that will make me a cultural idol, preferably one where the climate is mild, English is spoken, and the food is decent.

A second benefit of TQM is personal improvement. As each person increases his or her skills through training, the worth of each individual increases.

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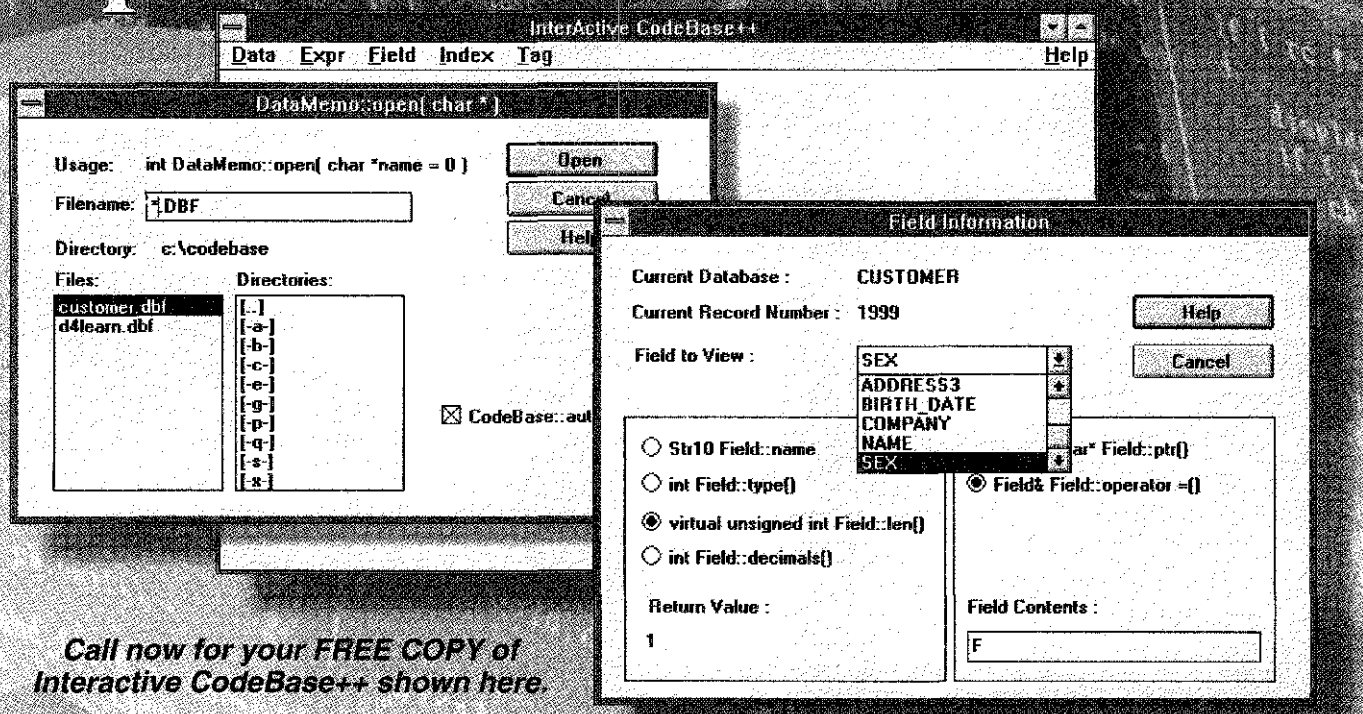

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```

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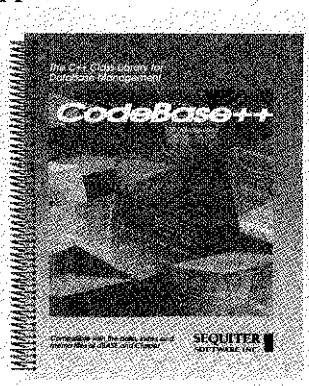

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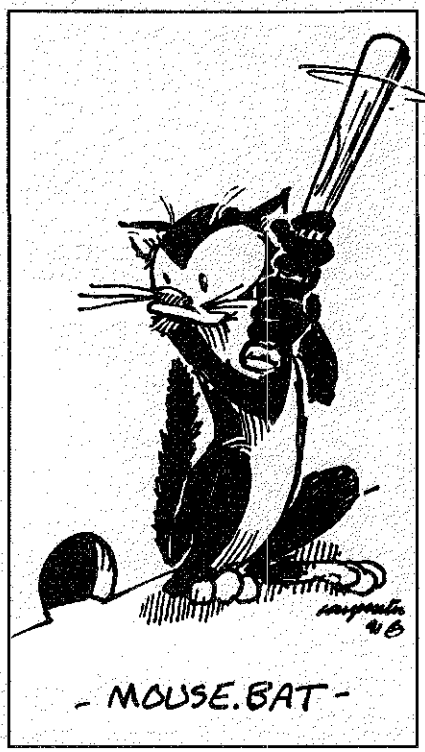
From a purely selfish point of view, TQM is worth doing because it makes you a better (as in more highly skilled) worker.

TQM's third benefit is that it improves the quality of life. When everyone works together to solve problems across the organization, routine screw-ups begin to decrease. Open communication reduces the problems attributable to lack of understanding. When you stop operating in a fire-fighting mode and start taking charge of your portion of the consulting business, you'll find that your work week gets a little more pleasant, and a little shorter, too. If the negative aspects of your job are affecting your personal life, you can expect some gradual changes there, as well. I haven't heard anyone say that TQM will improve your love life, but hey, it can't hurt.

If TQM sounds like it might help you with your practice, I suggest investing some serious effort in learning more about it. A one-day seminar might cover most of the concepts and explain them briefly, but assimilating TQM requires more work than that. You've got to really embrace it, and you've got to get everyone else in your company and preferably among your suppliers and customers to buy into it as well. The payoff can be enormous, but plan on many focused discussion sessions and applied exercises such as Process Improvement Teams.

Can the concepts of TQM actually affect the federal government? Consider this parallel phenomenon: at one time the label "Made in Japan" was synonymous with junk, but today, that same phrase means quality. If TQM can be instrumental in such a flip-flop, maybe some day it can change the status of the phrase "I'm from the government and I'm here to help you." Instead of being thought of as one of the top three archetypal lies, it might actually be taken seriously. ■



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Chips off the old block

By Dave Thompson

So you'd like a pen-based system, or maybe you're auditory and you're interested in voice recognition, or maybe you do a lot of compiles and you'd like to see a thousand-dollar clone that runs 50 MIPS, or how about a compiler that fixes your mistakes rather than yelling "Syntax Error"?

You can start the ball rolling by simply writing a press release. For instance, you could announce that you're "BMI Corp." and you'll be coming out with a thousand-dollar CRAY XT during the fourth quarter of 1993.

Now, send the release to a bunch of magazines. (Be sure to send me a copy; see below.) Chances are good that someone will run it. Then IBM, DEC, Microsoft, Borland—all those folks who watch new product announcements—will get excited, and they'll have to get cracking so they don't get left out and . . . Well, you get the picture.

NO CHIPS AT ALL?

Motorola just sent out a notice about their new PC-compatible floppy controller. The MCS3201 chip handles as many as four drives in any mix of 360K, 720K, 1.2MB, or 1.44MB. Motorola has included address decoding, variable-write precomp, data scan over a single sector or whole track, and DMA/non-DMA transfers. All you supply is 5V and a crystal. (Chips run $5 each in OEM quantities.)

Meanwhile, Elite's Eagle chip set, which supplies most of the glue for a 386DX, makes possible a complete cache-based motherboard with as few as 25 components. Now just add Motorola's floppy IC, a crystal, and presto zippo!

Just wait, though. When they start putting RAM on board the support chips we'll be seeing complete systems in

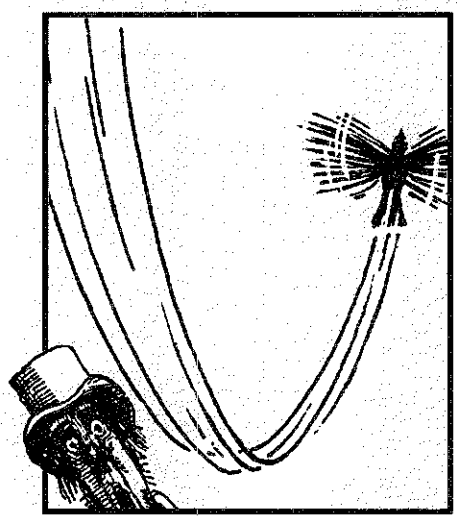

ILLUSTRATION BY JIM CARPENTER

three or four ICs. Make them out of CMOS and, who knows, you could have solar-powered, lap-loving screamers.

Or you could wait for Intel to come out with its next-generation 586 or whatever. They're supposed to be working on a single-chip system, glue and everything, in 300 pins or less.

OPENING MY MAIL

While roaming loose in the *PJ* offices recently, I happened upon the following piece of mail:

Dear Dave,

To our disappointment, you omitted mentioning our company's Siege and Besiege product lines. We're Mockingbird Communications, and our products are considered the best on the market in terms of performance, maturity, and user friendliness.

As you will be describing products like Siege and Beseige in an upcoming issue, I would like to take this opportunity to provide you with whatever information you require in order to include us in your article.

Yours truly,

I.M. Adement

P.S. If you run something about us in the next issue, you can ignore the two heavyset fellows stationed in the Mercedes across the street from the PJ offices.

P.P.S. If the mention is particularly positive, you can keep the Mercedes.

To which I made the following reply:

Dear I.M.,

Thanks for your letter. I'm sure readers would like to know more about your company, since they spend their lives working under Siege. Have you considered exporting your product to areas where it's truly needed? (The Middle East, Eastern Europe, New York City . . .)

LOOK AND FEEL OF FORTAN

PJ received another letter saying something about maintaining the look and feel of Fortran. Give me a break. I spent months in school solving calculus in Fortran (it was all we had). Assembly language would have been easier—it's more like English.

I prefer Pascal. It's like pseudo code. Heck, by the time I've got a problem written and debugged in Pascal I've come up with 20 additional features, all of which must be added. It's slow but it's fun, and I can spend months elaborating on something as simple as "Hello World." (For instance, this would be a great program for playing with compression algorithms.)

And speaking of playing, try C'ing for the first time, or after not writing C for a while (like half an hour). Wow! Just keeping the compiler from croaking is a challenge (and the comments you get from lint!). You can have so much fun with C that you forget why you're using it.

SON OF TECHTIPS

Those who remember *Micro Cornucopia* will remember Techtips, its most popular column. Readers sent in tips, and we printed the gems. You'll be delighted to know that *PJ* is now continuing this proud old tradition.

Tips can include algorithms, hardware fixes and breaks, cable diagrams, where to get parts or special kinds of software, interrupt vectors or other operating system insides, I/O interface hardware, and anything else of practical value that can be described in three

---

Dave Thompson is a former hardware/software engineer at Tektronix and the past editor of the prehistoric programming magazine Micro Cornucopia. *He can be reached at P.O. Box 223, Bend, OR 97709.*

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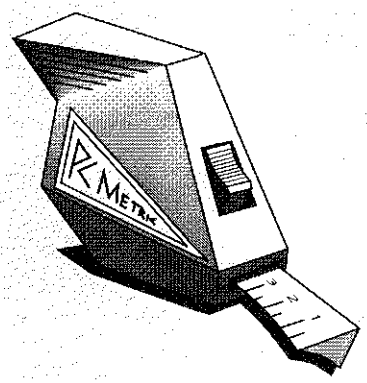

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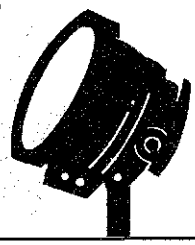

paragraphs or less and/or 20 lines of code. You can even throw in a very small schematic.

Write each tip on a separate piece of paper. Include your name, address, and phone number. Then send them to me at *Programmer's Journal*, P.O. Box 70167, Eugene, OR 97401-0110.

Authors will become famous, of course, and they'll also get an exclusive, authors-only T-shirt. At *Micro C*, we kept these highly coveted shirts in a plain, unmarked box concealed behind the renewal notices in the shipping department. Our bank refused to let us keep them in the safe deposit box after they learned that our readers were capable of waylaying electronic transfers. Wearers have even been offered bribes to sell the shirts off their backs.

So if you'd like to get a special package from *PJ*, all you have to do is send in one of those "Hey, did you know that with this little bit of code you can . . ." You don't even have to have made it up—just be the first to send it in. (Plus, your Techtip might supply a future "Programmer Bob" contestant with a great idea—see p. 49.)

WHY DON'T YOU WRITE ME

Now back to those press releases: if you come up with a product suggestion—funny or straight—or if you write or receive a particularly, shall we say, *interesting* press release, send that to me too, using the *PJ* post office box given above. (If you think I'm hungry for mail out here, you're absolutely right.) If it makes me laugh, I'll mention it.

The oxymoron for this month: Safe pesticide. PJ

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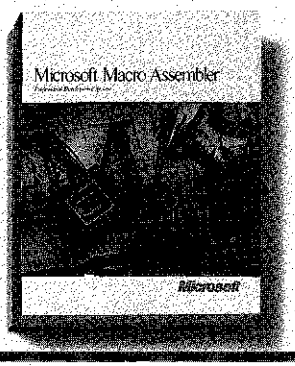

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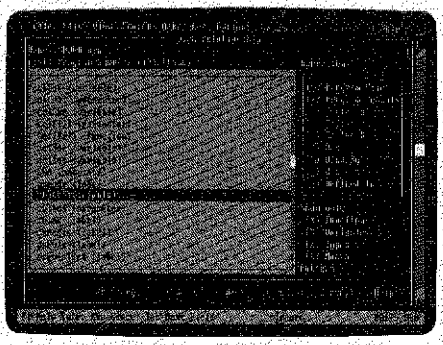

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New Features

- High-level language data types and control structures make mixed language programming easier. Including: PROTO/INVOKE, TYPEDEF, .IF/.THEN/.ELSE, and .REPEAT/.WHILE.
- Macro language extensions such as: @SubStr, @CatStr, @Date, & @Time.
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- Significantly improved Assembler speed.
- Programmer's WorkBench v 1.1 and CodeView® v 3.12 make it easier to develop stand-alone .asm and mixed-language programs.
- Source Browser gives instant access to data declarations and function definitions.

PROGRAMMER'S TIPS

The new INVOKE statement automates procedure calling, by handling all pushing and popping of parameters on the stack. Example:
INVOKE printf, ADDR fmt1st,
ADDR str2, dat1, dat2
If you want MASM 5.1 compatibility, start with the MASM.EXE compatibility driver or use the /Zm switch with ML.EXE.

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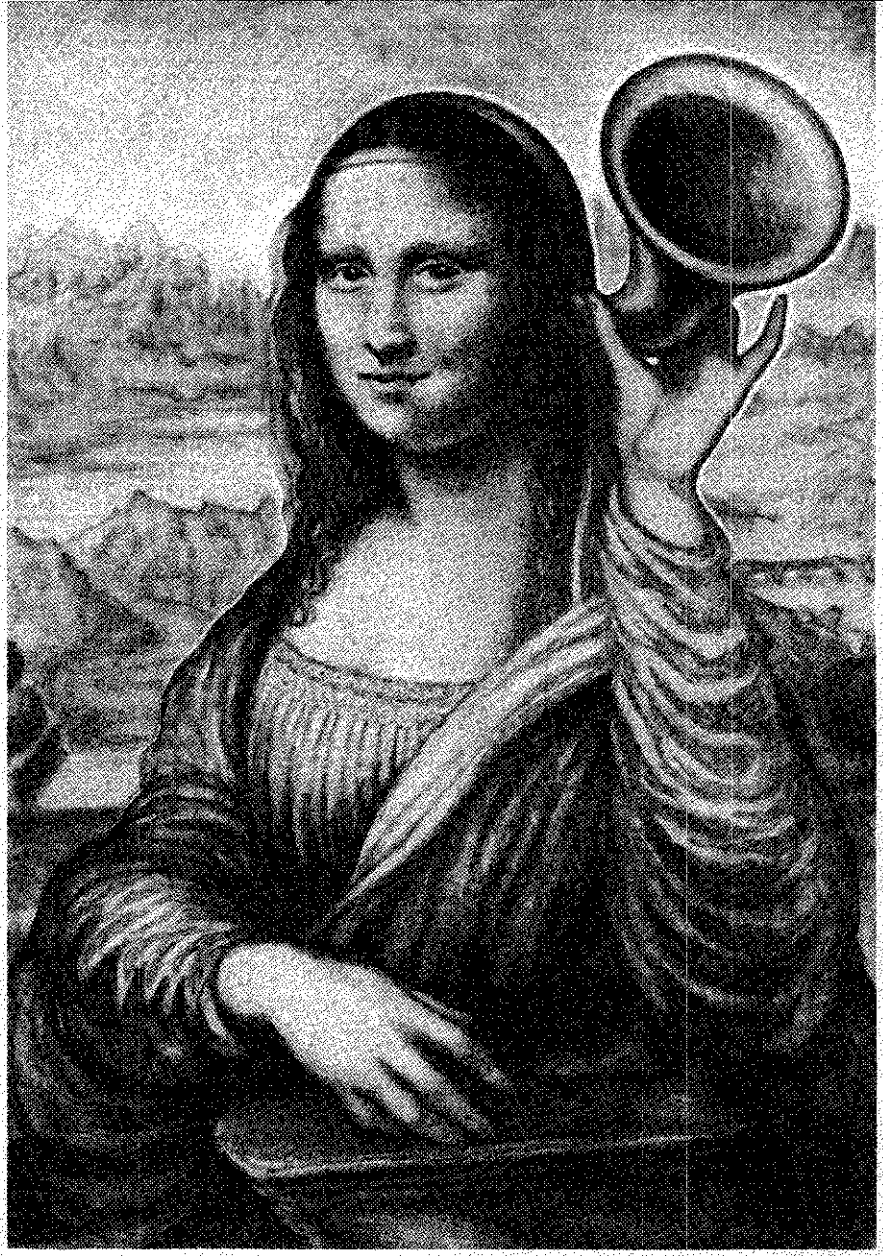

Multitasking operating systems thrive on the 80386 processor's built-in support for task switching and protection. Aspects of this protection include the hardware verification of a task's memory accesses and its optional accessing of I/O addresses. This latter capability lends itself perfectly to monitoring a task's I/O activity. Trapping and logging I/O accesses can be useful for debugging, black boxing, and educational and entertainment purposes.

This article describes IOM.EXE, an I/O monitoring program for the MS-DOS environment. To implement this task-protection feature, the program uses the 80386's protected and virtual-8086 modes. (See "Running unprotected," by Dean Wills, in *PJ* 8.4.)

Let's begin by reviewing the main data structure that supports multitasking.

LIMITED ACCESS

In 80386 protected mode, the task state segment (TSS) is the data area that holds the context of a task and static information, including other privilege-level stack segments and pointers and an optional I/O permission bitmap. This bitmap is what specifies which I/O addresses a task can access.

The I/O permission bitmap contains one bit for each address in the processor's I/O space. Because I/O addresses range from 0 to 65535, the bitmap can be as large as 8K. However, it only needs to be big enough to cover the maximum I/O address being tested. For example, if the highest I/O address to be tested is 119 (decimal), the bitmap only needs to be 16 bytes long (including the pad byte that must be placed at the end).

The processor locates the I/O permission map by adding the offset that is contained in the TSS's I/O map base field to the address at which TSS starts. It calculates the length of the I/O permission map by subtracting the I/O permission map offset from the limit of the TSS specified in the global descriptor table (GDT) entry for the TSS segment.

In protected mode, if a task's current privilege level (CPL) is less privileged (is numerically higher) than its I/O privilege level (IOPL), the I/O permission map is consulted to determine whether the task may access the particular I/O address.

In virtual-8086 mode, the processor consults the map regardless of the IOPL. If the corresponding permission map bit is set, the task cannot access the port. In such cases, a general protection exception (interrupt 0Dh) is generated. This exception is a fault; it enters the exception handler with the CS:EIP of the instruction as part of the information on the stack.

AN EYE ON I/O

The I/O monitoring program requires a number of steps. First, put the processor into protected mode and initialize all required areas; this includes setting bits in the TSS I/O permission bitmap for the I/O addresses that you wish to monitor. Second, create and execute a virtual-8086 task. This provides real-mode compatibility, allowing DOS and any applications to run within the restrictions that you impose via IOPL and the TSS.

When I/O accesses involving the specified range of ports are attempted, control is transferred to the interrupt 0Dh handler. If the instruction causing the exception is an I/O instruction, the I/O monitor temporarily clears the bits that correspond to the port(s) in the I/O permission bitmap; then it single steps through the instruction, stores the input or output data, and again sets the bits in the I/O permission bitmap.

Let's look at each of these steps in more detail.

In protected mode, segment registers are selectors that contain indices into

---

Rick Knoblaugh is a software engineer specializing in systems programming for microcomputers. He is a co-author of Screen Machine, a screen design/prototyping/code generation utility. He can be reached at P.O. Box 1109, Half Moon Bay, CA 94019.

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Eaves-dropping on I/O

Trapping and monitoring I/O port use on the 80386

By Rick Knoblaugh

either the global descriptor table (GDT) or the local descriptor table (LDT). Entries must be created in the GDT for each segment of memory to be used. These entries define the segment's size, type (executable, read only, or read/write), and other attributes.

Another difference between real and protected mode is that in protected mode, interrupts pass through gates in the interrupt descriptor table (IDT) rather than through the interrupt vectors. Thus, IDT entries are provided that point to handlers in the I/O monitor. These handlers either perform special interrupt processing or simply route the interrupts to the original interrupt service routines (via the real-mode interrupt vector table).

INTERRUPT HANDLING

In the PC environment, one complication of protected-mode programming is that certain protected-mode processor exceptions use the same interrupts as the hardware interrupts generated from IRQ0 to IRQ7. For example, IRQ5—typically used with LPT2—generates interrupt 0Dh. Note that 0Dh is the interrupt generated for the general protection exception discussed above. To avoid this conflict, I reprogrammed the master PIC so that interrupts start at 20h rather than at 08h.

Because V86 tasks execute with CPL = 3 and because we have specified IOPL = 3, *sensitive* instructions that require (CPL <= IOPL) can be executed. These instructions include I/O instructions and those, such as INT *n*, that directly affect the interrupt flag. Software interrupts do not go directly through the IDT gates, however, because all IDT entries have been defined with descriptor privilege level (DPL) set to zero. Thus, all software interrupts will cause a general protection exception (interrupt 0Dh). When the interrupt 0Dh handler detects this, it transfers control to the appropriate software interrupt routine.

After the GDT and IDT are established and loaded, you switch the processor to protected mode, load the task register with the index into the GDT for the TSS, and initialize the LDT to NULL (because the task will not make use of the LDT). Virtual-8086 mode is then entered by building a protected-mode interrupt stack frame, specifying that the VM bit in the EFLAGS be set (and that IOPL = 3) and setting CS:EIP so that the IRETD causes a transfer of control to the next instruction in the program. The code will execute as the virtual-8086 task. The I/O monitor then terminates and stays resident in your system.

DETECTING I/O

Interrupt 0Dh occurs when DOS, the BIOS, or other code attempts to execute an I/O instruction that accesses a monitored I/O port. The interrupt 0Dh handler then performs a table lookup on the instruction that caused the exception. If the instruction is an I/O instruction (supported by the table), the port address is stored and the corresponding TSS I/O permission map bits are cleared to allow the instruction to proceed. The trap bit is set in the EFLAGS so that a single-step trap (interrupt 1) will be generated after the I/O instruction executes. The I/O monitor interrupt 1 handler then records the input/output data and sets the I/O permission map bits again.

To demonstrate this technique, I have provided support in the code and instruction look-up table for basic 8- and 16-bit **in** and **out** instructions. To keep things simple, support for 32-bit I/O and I/O string instructions has been omitted.

Note that if these instructions are executed within the specified range to be monitored, the I/O monitor will display the address of the instruction and then stop. Monitoring these other instructions could be added with a little work.

The I/O monitor is invoked in the following way:

```
IOM startrange endrange
```


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LISTING 1

```
;Listing 1 contains a number of different files. Although they are separate
;on the code disk, they have been merged here for convenience.-- Ed.
;
;iomon.inc - equates for I/O Monitor
;
NULL            EQU     0
TRUE            EQU     -1
FALSE           EQU     NOT TRUE
BUF_SIZE        EQU     4096
DOS_PRT_STRING  EQU     9
DOS_TSR_FUNC    EQU     31h
OK              EQU     0
BEEP            EQU     7
CR              EQU     13
LF              EQU     10
TAB             EQU     9

USER_INT        EQU     61h             ;change this to another if it conflicts
PRESENT         EQU     80H
DPL0            EQU     0
DPL3            EQU     3
INT_GATE        EQU     0eh             ;80386 int gate
RW_DATA         EQU     92h             ;read/write data
ER_CODE         EQU     9ah             ;execute/read code
TSS_DESC        EQU     89h             ;Task State Segment descriptor
IO_MAP_SIZE     EQU     8192
TRAP_FLAG       EQU     100h            ;bits in eflags
INT_FLAG        EQU     200h
NT_FLAG         EQU     4000h
GEN_PROT_EXCEP  EQU     0dh             ;General Protection int number

INPUT           EQU     0               ;used in io_table to describe
OUTPUT          EQU     10h             ;the various I/O instructions
ABYTE           EQU     1
AWORD           EQU     2
CONSTANT        EQU     8

CONTAINS_DATA   EQU     80h
INT_OPCODE      EQU     0cdh
INT3_OPCODE     EQU     0cch
VID_PAGE_SIZE   EQU     4000
EXPECT_INT1     EQU     1
;
;macros for I/O monitor
DOINT           macro   num
int_&num        label   near
                PUBLIC  int_&num
                push    bp
                push    &num
                jmp     pass_thru
                endm

DOEXCP          macro   num
except_&num     label   near
                PUBLIC  except_&num
                push    bp
                push    &num
                jmp     except_handler
                endm

DOEXCPH         macro   num
int_&num        label   near
                PUBLIC  int_&num
                push    bp
                push    &num - 18h
                jmp     pass_thru
                endm

DEFIDT1         macro   num
                idt     <isrcode:int_&num,gdt_seg:sel_isrcode,,>
                endm

DEFIDTE         macro   num
                idt     <isrcode:except_&num,gdt_seg:sel_isrcode,,>
                endm
;
;structures for I/O monitor
idt             struc
i_offset        dw      ?
i_selector      dw      ?
i_unused        db      0
i_dpl_id        db      PRESENT + (DPL0 shl 5) + INT_GATE
i_offset2       dw      0
idt             ends

seg_descrip     struc
seg_limit_low   dw      ?
seg_base_low    dw      ?
seg_base_mid    db      ?
seg_type_dpl    db      ?
seg_limit_gran  db      ?
seg_base_top    db      ?
seg_descrip     ends

err_stack_area  struc                   ;stack with error code
e_pushed_int    dw      ?               ;int pushed by I/O monitor
e_pushed_bp     dw      ?               ;bp pushed by I/O monitor
e_errcode       dd      ?               ;error code
e_eip           dd      ?
e_cs            dw      2 dup(?)
e_eflags        dd      ?
e_esp           dd      ?
e_ss            dw      2 dup(?)
e_es            dw      2 dup(?)
e_ds            dw      2 dup(?)
e_fs            dw      2 dup(?)
e_gs            dw      2 dup(?)
err_stack_area  ends

stack_area      struc                   ;stack without error code
s_pushed_int    dw      ?               ;int pushed by I/O monitor
s_pushed_bp     dw      ?               ;bp pushed by I/O monitor
s_eip           dd      ?
s_cs            dw      2 dup(?)
s_eflags        dd      ?
s_esp           dd      ?
s_ss            dw      2 dup(?)
s_es            dw      2 dup(?)
s_ds            dw      2 dup(?)
s_fs            dw      2 dup(?)
s_gs            dw      2 dup(?)
stack_area      ends

user_stack      struc
user_ip         dw      ?
user_cs         dw      ?
user_flags      dw      ?
user_stack      ends

psp             struc
                db      80h dup(?)
arg_len         db      ?
arg_off         db      ?
psp             ends

doub_word       struc
d_offset        dw      ?
d_segment       dw      ?
doub_word       ends

io_struc        struc
io_opcode       db      ?
io_info         db      ?
io_struc        ends

buf_record      struc                   ;format of logged data
buf_info        db      ?
buf_port        dw      ?
buf_data        dw      ?
buf_record      ends

tss_dat         struc
t_backlink      dw      2 dup(?)
t_esp0          dd      ?
t_ess0          dw      2 dup(?)
t_esp1          dd      ?
t_ess1          dw      2 dup(?)
t_esp2          dd      ?
t_ess2          dw      2 dup(?)
t_cr3           dd      ?
t_eip           dd      ?
t_eflags        dd      ?
t_eax           dd      ?
t_ecx           dd      ?
t_edx           dd      ?
t_ebx           dd      ?
t_esp           dd      ?
t_ebp           dd      ?
```

continued

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where **startrange** and **endrange** are the starting and ending addresses (in hex) of the range of I/O ports to be monitored. Both must be specified.

TIME TO GET TO WORK

For example, to monitor I/O activity to LPT1, you would enter

```
IOM 378 37f
```

You shouldn't specify a broad range or one that includes a port that is accessed constantly, such as 20h or A0h: the I/O monitor round robin storage buffer would be filled instantly.

To retrieve a pointer to the I/O monitor storage buffer, execute user interrupt 61h. You can change this to another interrupt if it competes with some other program. A far pointer to the buffer will be returned in DX:BX. The code disk includes IODISP.C, which demonstrates retrieving the data.

You shouldn't specify a broad range to be monitored, or one that includes a port that is accessed constantly, such as 20h or A0h.

WORDS TO THE WISE

Because real-mode software debuggers can't be used, debugging protected-mode programs such as this I/O monitor can be a challenge. If, like me, you don't have an in-circuit emulator, you will need to be patient and reset your machine often.

I hope the template for protected-mode initialization given here is useful. When employing this code for other protected-mode applications, be sure to enable the A20 line if you intend to address more than 1MB. You might also want to investigate INT 15h function 89h, which can be used for much of the initialization. PJ

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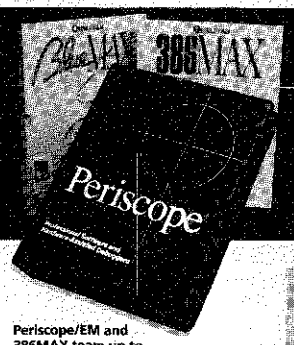

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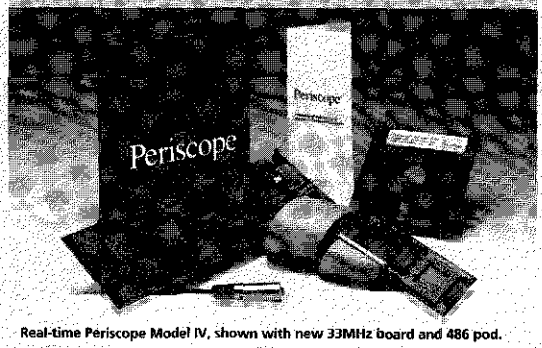

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```
t_esi           dd      ?
t_edi           dd      ?
t_es            dw      2 dup(?)
t_cs            dw      2 dup(?)
t_ss            dw      2 dup(?)
t_ds            dw      2 dup(?)
t_fs            dw      2 dup(?)
t_gs            dw      2 dup(?)
t_ldt           dw      2 dup(?)
t_tbit          dw      ?
t_iobase        dw      ?
t_iomap         db      IO_MAP_SIZE     dup(?)
t_iopad         dw      0ffh            ;follow last map byte with 0ffh
tss_dat         ends
```

LISTING 2

```
;iodat.inc - data for I/O Monitor
;
iostack3        segment para stack 'STACK' use16
io_stack3       dw      256 dup('S')
io_sp3          label   word
iostack3        ends

iostack         segment para public 'STACK' use16
STACK_BEG       EQU     $
io_stack        dw      256 dup('S')
io_sp           label   word
STACK_END       EQU     $
iostack         ends

gdt_seg         segment para public 'data16' use16
                public  sel_databs
                public  sel_stack
                public  sel_video
                public  sel_data
                public  sel_tss_alias

GDT_BEG         EQU     $
sel_null        seg_descrip     <>
sel_tss         seg_descrip     <>
sel_tss_alias   seg_descrip     <>
sel_gdt_alias   seg_descrip     <>
sel_isrcode     seg_descrip     <>
sel_code        seg_descrip     <>
sel_databs      seg_descrip     <>
sel_stack       seg_descrip     <>
sel_video       seg_descrip     <>
sel_data        seg_descrip     <>
GDT_END         EQU     $
gdt_seg         ends

idt_seg         segment para public 'data16' use16
IDT_BEG         EQU     $
                DEFIDTI 0
idt     <isrcode:int1_isr,gdt_seg:sel_isrcode,,PRESENT+(DPL0 shl 5)+INT_GATE,>
                DEFIDTI 2
                idt     <,,,PRESENT + (DPL0 shl 5) + INT_GATE,>

                irp     z, <4, 5, 6, 7>
                DEFIDTI &z
                endm

                irp     z, <8, 9, 0ah, 0bh, 0ch, 0dh, 0eh, 0fh>
                DEFIDTE &z
                endm

 idt        (1fh - 0fh)  dup(<,,,PRESENT + (DPL0 shl 5) + INT_GATE,>)

                irp     z, <20h, 21h, 22h, 23h, 24h, 25h, 26h, 27h>
                DEFIDTI &z
                endm
 idt        (6Fh - 27h)  dup(<,,,PRESENT + (DPL0 shl 5) + INT_GATE,>)

                irp     z, <70h, 71h, 72h, 73h, 74h, 75h, 76h, 77h>
                DEFIDTI &z
                endm

IDT_END         EQU     $
idt_seg         ends

data            segment para public 'data16' use16
                public  start_port
                public  end_port
                public  old_int1
                public  old_user_int
                public  io_table
                public  IO_TAB_ENTRIES
                public  access_port
                public  access_info
                public  store_buf
                public  store_buf_end
                public  store_ptr
                public  display_loc
                public  trap_status

DATA_BEG        EQU     $
bad_2nd_msg     db      '2nd port number must be >= first port.', BEEP, CR,
LF, '$'
bad_arg_msg     db      'Invalid port address specified.', BEEP, CR, LF, '$'
start_port      dw      0
end_port        dw      0
old_int1        dd      ?
old_user_int    dd      ?
access_port     dw      ?
access_info     db      ?
trap_status     db      0

io_table        io_struc        <0e4h, INPUT+CONSTANT+ABYTE>
                io_struc        <0e5h, INPUT+CONSTANT+AWORD>
                io_struc        <0e6h, OUTPUT+CONSTANT+ABYTE>
                io_struc        <0e7h, OUTPUT+CONSTANT+AWORD>
                io_struc        <0ech, INPUT+ABYTE>
                io_struc        <0edh, INPUT+AWORD>
                io_struc        <0eeh, OUTPUT+ABYTE>
                io_struc        <0efh, OUTPUT+AWORD>
IO_TAB_ENTRIES  EQU     ($ - io_table)/size io_struc

store_buf       db      BUF_SIZE dup(0)
store_buf_end   equ     $
store_ptr       dw      offset store_buf

gdtl            EQU     THIS FWORD
gdtlim          dw      (GDT_END-GDT_BEG)-1
gdtadrs         dd      ?

idtl            EQU     THIS FWORD
idtlim          dw      (IDT_END-IDT_BEG)-1
idtadrs         dd      ?

display_loc     dw      0               ;offset into video page
DATA_END        EQU     $
data            ends

tss_seg         segment para public 'data16' use16
TSS_BEG         EQU     $
                tss_dat <>
TSS_END         EQU     $
tss_seg         ends
```

LISTING 3

```
;ioinit (main) and ioisr modules for I/O Monitor merged for convenience
;Copyright 1991 ASMicro Co. 5/19/91  Rick Knoblaugh

                .386P
                include iomon.inc
                include iodat.inc
isrcode         segment para public 'icode16' use16   ; must define first
isrcode         ends
code            segment para public 'code16' use16
                assume cs:code, ds:data, es:data

start           proc    far
                push    ds              ;save psp seg
                mov     ax, data
                mov     es, ax
                call    get_args        ;get io ports
                mov     ax, data
                mov     ds, ax
                jnc     start_200       ;continue if args  ok
start_100:      mov     ah, DOS_PRT_STRING
                int     21h
                mov     ax, 4c01h
                int     21h
start_200:      call    setup_ints      ;take over user int

                call    init_gdt
                call    init_tss
```

continued

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```
                mov     ax, data
                mov     ds, ax
                assume  ds:data

                cli                     ;no ints until protected mode

                mov     ax, gdt_seg
                movzx   eax, ax
                shl     eax,  4
                mov     gdtadrs, eax

                mov     ax, idt_seg
                movzx   eax, ax
                shl     eax,  4
                mov     idtadrs, eax

                call    reprogram_pic

                lgdt    gdtl
                lidt    idtl

                mov     dx, iostack3    ;get stack segment
                mov     bx, sp          ;and pointer
                mov     eax, cr0
                or      eax, 1          ;turn on protected mode bit
                mov     cr0, eax        ;go into protected mode

;jump to clear prefetch queue
                db      0eah            ;far jump
                dw      offset code:start_400
                dw      gdt_seg:sel_code
start_400:      mov     ax, offset gdt_seg:sel_tss
                ltr     ax
                xor     ax, ax
                lldt    ax              ;null ldt
                mov     ax, seg data
                movzx   eax, ax
                push    eax             ;null gs
                push    eax             ;null fs
                push    eax             ;null ds
                push    eax             ;null es

                push    0
                push    dx              ;stack segment
                push    0
                push    bx              ;stack pointer

                push    2               ;VM bit set in upper eflags
                push    3000h           ;NT=0, IOPL=3, CLI in lower eflags
                push    0
                push    seg code        ;cs of where to return
                push    0
                push    offset code:start_500  ;ip of where to return

;Must ensure that Nested Task bit is not set in eflags.  If it were,
;processor would attempt to switch to a task via the selector in
;the TSS backlink field.  Since that field is now zero, an invalid TSS
;fault would occur.
                pushf
                pop     ax
                and     ax, NOT NT_FLAG
                push    ax
                popf
                iretd
start_500:      pop     bx                  ;begin vm86 task here
                sti                         ;get saved psp seg
                mov     dx, code + 1        ;interrupts ok now
                sub     dx, bx              ;init code we are dropping
                mov     al, OK              ;exit code
                mov     ah, DOS_TSR_FUNC
                int     21h
start           endp

reprogram_pic   proc    near
                in      al, 21h
                mov     ah, al
                mov     al, 11h         ;init
                out     20h, al
                mov     al, 20h         ;irq0 to int 20h
                out     21h, al
                jmp     short $ + 2
                jmp     short $ + 2
                mov     al, 4
                out     21h, al
                jmp     short $ + 2
```

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```
                jmp     short $ + 2
                mov     al, 1
                out     21h, al
                jmp     short $ + 2
                jmp     short $ + 2
                mov     al, ah
                out     21h, al
                ret
reprogram_pic   endp

;get_args - retrieve starting and ending i/o addresses from
;           the command line.
;           Enter:  ds=PSP seg
;           Exit:  If invalid, carry set and dx=offset msg
get_args        proc    near
                cld
                xor     si, si
                sub     ch, ch
                mov     cl, [si].arg_len        ;get cmd line length
                lea     si, [si].arg_off        ;and offset
                call    skip_white_sp
                mov     dx, offset es:bad_arg_msg
                jcxz    get_a800                ;if no args
                call    get_validate            ;get first i/o port
                jc      get_a999
                mov     es:start_port, bx       ;save it
                call    skip_white_sp
                jcxz    get_a800                ;if no 2nd arg
                call    get_validate            ;get 2nd i/o port
                jc      get_a999
                mov     es:end_port, bx         ;save it
                cmp     bx, es:start_port       ;2nd arg >= 1st arg
                jae     get_a900
                mov     dx, offset es:bad_2nd_msg
get_a800:       stc
                jmp     short get_a999
get_a900:       clc
get_a999:       ret
get_args        endp

;get_validate - Retrieve and validate an ASCII hex number.
;               Enter: si ptr to data
;                      cx max len
;               Exit: data at si now binary
;                     cx decremented by length of number
;                     If invalid, carry set and dx=&err_msg
;                     bx=binary value of number
get_validate    proc    near
                xor     bx, bx
get_v100:       cmp     byte ptr [si + bx], ' '
                je      get_v200
                cmp     byte ptr [si + bx], CR
                je      get_v200
                inc     bx
                jmp     short get_v100
get_v200:       sub     cx, bx                  ;cmd line chars left
                push    cx
                mov     cx, bx
                xor     bx, bx
get_v300:       sub     ah, ah
                lodsb                           ;get a digit
                call    asc2bin                 ;validate and convert
                jc      get_v900                ;exit if invalid
                push    cx
                jcxz    get_v500
                dec     cx                      ;position from right - 1
                shl     cl, 2
                shl     ax, cl                  ;get nibble into position
get_v500:       or      bx, ax                  ;build number
                pop     cx
                loop    get_v300
                clc                             ;ok
get_v900:       pop     cx
                ret
get_validate    endp

asc2bin         proc    near
                cmp     al,  'a'
                jb      asc2b_100
                and     al, 0dfh                ;force to upper case
asc2b_100:      cmp     al, '0'
                jb      asc2b_800
                cmp     al, '9'                 ;see if 0-9 or A-F
                ja      asc2b_500
                sub     al, '0'                 ;convert to binary
                jmp     short asc2b_600

asc2b_500:      cmp     al, 'F'
                ja      asc2b_800
                sub     al, 'A' - 10
asc2b_600:      clc
                jmp     short asc2b_900
asc2b_800:      mov     dx, offset es:bad_arg_msg
                stc
asc2b_900:      ret
asc2bin         endp

skip_white_sp   proc    near
                cmp     byte ptr [si], ' '
                je      skip_w200
                cmp     byte ptr [si], TAB
                je      skip_w200
                jmp     short skip_w900
skip_w200:      inc     si
                loop    skip_white_sp
skip_w900:      ret
skip_white_sp   endp

setup_ints      proc    near
                mov     bx, USER_INT
                mov     di, offset old_user_int
                mov     cx, isrcode
                mov     dx, offset isrcode:user_int_isr
                call    get_int
                ret
setup_ints      endp

;get_int - For a given interrupt vector, store contents and
;          load with new isr address.
;          bx = int number
;          es:di = location to store contents
;          dx = offset new isr
;          cx = cs of new isr
get_int         proc    near
                cld
                push    ds
                xor     ax, ax
                mov     ds, ax
                shl     bx, 2
                mov     ax, [bx]
                stosw
                mov     ax, [bx].d_segment
                stosw
                cli
                mov     [bx].d_offset, dx
                mov     [bx].d_segment, cx
                sti
                pop     ds
                ret
get_int         endp

init_gdt        proc    near
                mov     ax, gdt_seg
                mov     ds, ax
                assume  ds:gdt_seg

                mov     dx, tss_seg
                movzx   edx, dx                 ;base data segment
                mov     ecx, (TSS_END - TSS_BEG ) - 1  ;limit
                mov     ah, TSS_DESC
                mov     si, offset sel_tss
                call    make_entry

                mov     dx, tss_seg
                movzx   edx, dx                 ;base data segment
                mov     ecx, (TSS_END - TSS_BEG ) - 1  ;limit
                mov     ah, RW_DATA             ;alias as r/w for editing
                mov     si, offset sel_tss_alias
                call    make_entry

                mov     dx, gdt_seg
                movzx   edx, dx                 ;base data segment
                mov     ecx, (GDT_END - GDT_BEG ) - 1  ;limit
                mov     ah, RW_DATA             ;alias as r/w for editing
                mov     si, offset sel_gdt_alias
                call    make_entry

                mov     dx, isrcode
                movzx   edx, dx                 ;base of isr code segment
                mov     ecx, 0ffffh             ;max segment size
```

continued

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```
                mov     ah, ER_CODE
                mov     si, offset sel_isrcode
                call    make_entry

                mov     dx, code
                movzx   edx, dx                 ;base code segment
                mov     ecx, 0ffffh             ;max segment size
                mov     ah, ER_CODE
                mov     si, offset sel_code
                call    make_entry

                xor     edx, edx                ;zero base
                mov     ecx, 0fffffh            ;base memory size
                mov     ah, RW_DATA
                mov     si, offset sel_databs
                call    make_entry

                mov     dx, iostack
                movzx   edx, dx                 ;base stack segment
                mov     ecx, (STACK_END - STACK_BEG  ) - 1  ;limit
                mov     ah, RW_DATA
                mov     si, offset sel_stack
                call    make_entry

                mov     dx, data
                movzx   edx, dx                 ;base data segment
                mov     ecx, (DATA_END - DATA_BEG  ) - 1  ;limit
                mov     ah, RW_DATA
                mov     si, offset sel_data
                call    make_entry

                int     11h                     ;equipment check
                mov     edx, 0b800h             ;color segment
                and     al, 30h                 ;monitor bits
                cmp     al, 30h                 ;30h=monochrome
                jne     short init_gdt500
                mov     edx, 0b000h             ;monochrome segment
init_gdt500:    mov     ecx, VID_PAGE_SIZE - 1  ;page size - 1
                mov     ah, RW_DATA
                mov     si, offset sel_video
                call    make_entry
                ret
init_gdt        endp

;make_entry - Load a GDT entry from information passed as follows:
;             ds=gdt segment
;             si=offset of gdt entry to load
;             ah=type | dpl
;            ecx=limit
;            edx=base segment (convert it to linear)
;            Always set for byte granularity and 16 bit size
make_entry      proc    near
                shl     edx, 4                  ;convert seg to linear
                mov     [si].seg_limit_low, cx
                mov     [si].seg_base_low, dx
                shr     edx, 16
                mov     [si].seg_base_mid, dl
                mov     [si].seg_type_dpl, ah
                shr     ecx, 16
                and     cl, 0fh                 ;limit and byte gran
                mov     [si].seg_limit_gran, cl
                mov     [si].seg_base_top, dh
                ret
make_entry      endp

;init_tss - Initilize TSS with base of I/O bit map and set
;          appropriate bits in I/O bit map per cmd line.
init_tss        proc    near
                mov     ax, tss_seg
                mov     ds, ax
                assume  ds:tss_seg
                xor     si, si

                mov     ax, offset gdt_seg:sel_stack
                mov     [si].t_ess0, ax
                mov     ax, offset iostack:io_sp
                movzx   eax, ax
                mov     [si].t_esp0, eax

                lea     bx, [si].t_iomap
                mov     [si].t_iobase, bx

                mov     cx, es:start_port       ;start of range to monitor
                mov     dx, cx
                and     cl, 7                   ;get non byte boundary
                mov     al, 1                   ;first bit position
                shl     al, cl                  ;get out corresponding bit
                shr     dx, 3                   ;start_port/8
                mov     cx, es:end_port
                sub     cx, es:start_port
                inc     cx
                add     bx, dx                  ;starting offset in map
init_t100:      or byte ptr [bx], al            ;turn on permission bit
                rcl     al, 1                   ;next bit position
                jnc     init_t300
                inc     bx
                rcl     al, 1
init_t300:      loop    init_t100
                ret
init_tss        endp
code ends

isrcode         segment para public 'code16' use16
                assume cs:isrcode, ds:nothing, es:nothing

;Interrupt Service Routines for I/O Monitor

        irp     z, <0, 2, 3, 4, 5, 6, 7>
        DOINT   &z
        endm

        irp     z, <8, 9, 0ah, 0bh, 0ch, 0dh, 0eh, 0fh>
        DOEXCP  &z
        endm

        irp     z, <20h, 21h, 22h, 23h, 24h, 25h, 26h, 27h>
        DOEXCPH &z
        endm

        irp     z, <70h, 71h, 72h, 73h, 74h, 75h, 76h, 77h>
        DOINT   &z
        endm

;int1_isr -  ISR for single step interrupt.  If trap_status
;            has EXPECT_INT1 bit set, this is the trap
;            that occurs just after the I/O instruction
;            we are monitoring executes.  Store the I/O data
;            from ax into our buffer.
int1_isr        proc    far
                push    bp
                mov     bp, sp
                push    bx
                push    ds
                mov     bx, offset gdt_seg:sel_data
                mov     ds, bx
                assume  ds:data
                test    trap_status, EXPECT_INT1 ;expecting an int 1?
                jnz     int1_050
                pop     ds
                pop     bx
                push    1
                jmp     pass_thru               ;if not, do old int 1
 int1_050:      push    ax
                push    cx
                push    dx
                mov     trap_status, 0
                and     [bp].s_eflags, NOT TRAP_FLAG ;no more single step
                mov     bx, store_ptr
                mov     cl, access_info
                or      cl, CONTAINS_DATA       ;indicate data stored
                mov     [bx].buf_info, cl       ;store info re i/o
                mov     dx, access_port
                mov     [bx].buf_port, dx       ;store port number
                test    cl, AWORD               ;word access?
                jnz     int1_100
                sub     ah, ah                  ;if not, clear half
int1_100:       mov     [bx].buf_data, ax
                add     bx, size buf_record     ;advance buf ptr
                cmp     bx, store_buf_end - size buf_record  ;at end?
                jb      int1_200
                mov     bx, offset store_buf
int1_200:       mov     store_ptr, bx           ;save new ptr
                and     cx, (AWORD OR ABYTE)    ;number of bits
                mov     ah, 1                   ;indicate set
                mov     dx, access_port
                call    do_bit_map      ;set the bits again
                pop     dx
                pop     cx
                pop     ax
                pop     ds
```

continued

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```
                pop     bx
                pop     bp
                iretd
int1_isr        endp

;except_handler - Process as follows:
;                       Int 0dh - Go look for software int or
;                                 I/O instruction.
;                       Any other
;                       exception - go display exception number
;                                   and halt.
except_handler  proc    near
                mov     bp, sp
                cmp     [bp].e_pushed_int , GEN_PROT_EXCEP
                je      gen_prot_isr
                mov     ax, [bp].e_pushed_int ;int in ax, go display
                jmp short fatal_error
except_handler  endp

fatal_error     proc    near
                call    display_it
                jmp     $
fatal_error     endp

;display_it - Display hex number on screen at next display offset
;            Enter:  number in AX processor in protected mode
;            All registers saved
display_it      proc    near
                pusha
                push    ds
                push    es

                mov     dx, offset gdt_seg:sel_data
                mov     ds, dx                  ;get our data segment
                assume  ds:data
                mov     dx, offset gdt_seg:sel_video
                mov     es, dx                  ;and video segment
                mov     di, display_loc
                xchg    al, ah                  ;print MSB first
                call    put_hex_digit
                xchg    al, ah                  ;get LSB
                call    put_hex_digit
                add     di, 2                   ;past space and attribute
                cmp     di, VID_PAGE_SIZE
                jb      display_i100
                xor     di, di                  ;back to start of page
 display_i100:  mov     display_loc, di
                pop     es
                pop     ds
                popa
                ret
display_it      endp

put_hex_digit   proc    near
                push    ax
                mov     cx, 2                   ;2 digits in al
                mov     ah, al
put_hex_100:    shr     al, 4
                cmp     al, 9
                ja      put_hex_200
                add     al, '0'
                jmp     short put_hex_300
put_hex_200:    add     al, 'A' - 10
put_hex_300:    cld
                stosb
                inc     di                      ;past attrib
                mov     al, ah
                shl     al, 4
                loop    put_hex_100
                pop     ax
                ret
put_hex_digit   endp

;pass_thru - This procedure is JMPed to by any interrupt handler that
;            wishes to pass control to the original ISR per the
;            interrupt vector table.
;            Entry:
;                 See stack_area struc for stack layout.
;                 Any error code has been removed from stack.
;                 EIP on stack has been adjusted if
;                 necessary.
pass_thru       proc    near
                mov     bp, sp
                pushad
                push    ds
                mov     ax, offset gdt_seg:sel_databs
                mov     ds, ax                  ;address all base memory
                movzx   ebx, [bp].s_ss          ;user stack
                shl     ebx, 4                  ;make linear
                mov     edx, [bp].s_esp         ;user stack pointer
                sub     edx, 6                  ;flags, cs, ip
                mov     [bp].s_esp, edx         ;adjust it
                mov     eax, [bp].s_eflags      ;put on flags
                mov     [ebx][edx].user_flags, ax

;change flags on stack so that original ISR will be entered with
;interrupts cleared and trap flag cleared to be consistent with their
;state upon entering an ISR (the normal way).
                and     ax, not (TRAP_FLAG + INT_FLAG)
                mov     [bp].s_eflags, eax      ;put back flags
                mov     ax, [bp].s_cs           ;put on user cs
                mov     [ebx][edx].user_cs, ax
                mov     eax, [bp].s_eip         ;put on ip
                mov     [ebx][edx].user_ip, ax
                movzx   ebx, [bp].s_pushed_int  ;get int number
                movzx   eax, [ebx * 4].d_offset ;offset portion
                mov     [bp].s_eip, eax
                mov     ax, [ebx * 4].d_segment ;segment portion
                mov     [bp].s_cs, ax
                pop     ds
                popad
                add     sp, 2                   ;get rid of int number
                pop     bp
                iretd
pass_thru       endp

;gen_prot_isr - JMP here if int 0dh.  Process as follows:
;               Look for software int.  If found, go route to
;               appropriate ISR.
;
;               Look for I/O instructions we currently
;               support.  If found, store port, size and
;               direction of I/O.  Also, set trap flag and
;               return (we will get control at int 1 to
;               inspect data).
;
;               If other than software int or I/O, go
;               display 0dh and halt.
gen_prot_isr    proc    near
                push    ds
                pushad
                mov     bx, offset gdt_seg:sel_databs
                mov     ds, bx
                movzx   ebx, [bp].e_cs  ;get cs of user instruction
                shl     ebx, 4          ;make linear
                add     ebx, [bp].e_eip ;add ip
                mov     ax, [ebx]       ;get bytes at cs:ip
                cmp     al, INT_OPCODE
                jne     get_prot100
                inc     [bp].e_eip      ;get past the 0cdh
get_prot050:
                inc     [bp].e_eip

;Adjust stack so that error code goes away and int number retrieved from
;instruction goes in spot on stack where pushed int number is (for stacks
;with no error code).  Stack will be the way pass_thru routine likes it.
                mov     bx, [bp].e_pushed_bp
                shl     ebx, 16         ;get into high word
                mov     bl, ah          ;interrupt number
                mov     [bp].e_errcode, ebx
                popad
                pop     ds
                add     sp, 4           ;error code gone
                jmp     pass_thru
get_prot100:    cmp     al, INT3_OPCODE
                jne     get_prot150
                mov     ah, 3           ;interrupt 3
                jmp     short get_prot050
get_prot150:    mov     bx, offset gdt_seg:sel_data
                mov     ds, bx
                mov     bx, offset io_table
                mov     cx, IO_TAB_ENTRIES
get_prot200:    cmp     al, [bx].io_opcode
                jne     get_prot300
                mov     trap_status, EXPECT_INT1
                mov     cl, [bx].io_info ;get info about instruction
                mov     access_info, cl
                mov     access_port, dx  ;save port
                test    cl, CONSTANT     ;is port number in instruction?
                jz      get_prot250      ;if not, we have it
```

continued

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```
                xchg    ah, al          ;ah = 2nd byte of instruction
                sub     ah, ah
                mov     access_port, ax ;save port
                mov     dx, ax
get_prot250:    and     cx, (AWORD OR ABYTE)   ;number of bits
                sub     ah, ah          ;indicate clear
                call    do_bit_map

                popad
                pop     ds
                or      [bp].e_eflags, TRAP_FLAG ;single step i/o

                add     sp, 2           ;int number pushed
                pop     bp
                add     sp, 4           ;error code
                iretd
get_prot300:    add     bx, size io_struc ;advance to next table entry
                loop    get_prot200
                mov     ax, [bp].e_cs   ;get cs of user instruction
                call    display_it
                mov     eax, [bp].e_eip ;add ip
                call    display_it
                popad
                pop     ds
                mov     ax, [bp].e_pushed_int
                jmp     fatal_error
gen_prot_isr    endp

;do_bit_map - For the number of ports specified, clear/set
;             corresponding I/O permission map bits.
;             Enter:  Ah = 0 clear, ah = 1 set
;                     dx = starting port
;                     cx = number of ports
;  All registers saved.

do_bit_map      proc    near
                push    ax
                push    bx
                push    cx
                push    dx
                push    ds
                mov     bx, offset gdt_seg:sel_tss_alias
                mov     ds, bx
                assume  ds:tss_seg
                mov     bx, t_iomap
                push    cx
                mov     cx, dx                  ;port
                and     cl, 7                   ;get non byte boundary
                mov     al, 1                   ;first bit position
                shl     al, cl                  ;get out corresponding bit
                shr     dx, 3                   ;start_port/8
                pop     cx
                add     bx, dx                  ;starting offset in map
do_bit100:      or      ah, ah
                jnz     do_bit200
                mov     dl, al
                not     dl
                and     byte ptr [bx], dl       ;turn off permission bit
                jmp     short do_bit250
do_bit200:      or byte ptr [bx], al            ;turn on permission bit
do_bit250:      rcl     al, 1                   ;next bit position
                jnc     do_bit300
                inc     bx
                rcl     al, 1
do_bit300:      loop    do_bit100
                pop     ds
                pop     dx
                pop     cx
                pop     bx
                pop     ax
                ret
do_bit_map      endp


;user_int_isr - return buffer address to caller.
;             Exit: dx:bx= far ptr to store_buf

user_int_isr    proc    near
                mov     dx, data
                mov     bx, offset data:store_buf
                iret
user_int_isr    endp
isrcode         ends

                end start
```


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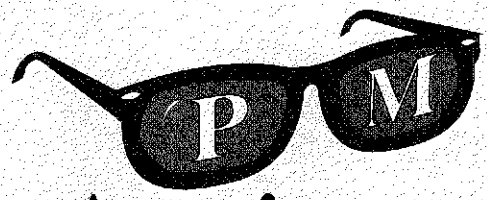

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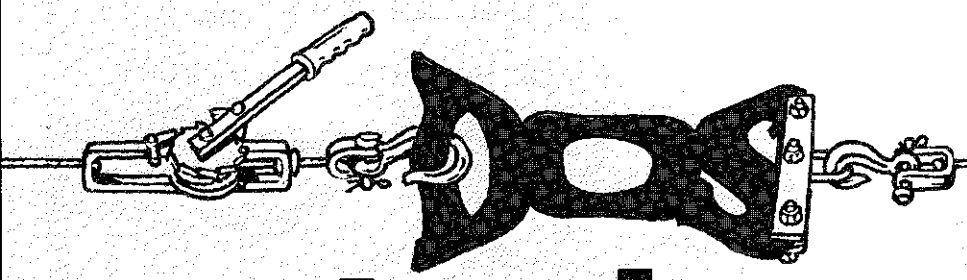

extenders

Stretching the limits

By M. Steven Baker

DOS has incredible staying power. Although it won't be long before Intel releases 80586 chips, MS-DOS—the dominant operating system on the *x*86 chips—has seen only modest changes since version 2.0. DOS 3 added 16-bit FATs and network support, but versions 3.0 and 3.2 were terribly bug-ridden. Compaq DOS 3.31 and DOS 4.*x* broke the 32MB disk-partition barrier—a feat that third-party software such as SpeedStor, Disk Manager, Vopt, and Compaq's EXTDISK.SYS had accomplished some time earlier.

DOS 5 is a welcome improvement over its predecessors, even though many of the features it adds should have been available since the introduction of Windows 2.1 and HIMEM.SYS. The PC world has benefited from the feature in the 80286 chip that allowed an extra 64K (minus 16 bytes) of memory to be accessible when segment address FFF0 was used. DOS 5 exploits this bug/feature to load much of DOS into that magic-memory land; of course, Windows 2 used the same technique when using HIMEM.SYS way back when. At long last, DOS 5 sports a decent visual shell for those who dislike the DOS prompt. This shell represents a trade-off between user interface and memory for DOS applications. On a 386, a modest task switcher has been added. Some valuable utilities (the UNDELETE and UNFORMAT commands from Central Point Software) are also incorporated, but DOS 5 brings little new to the overall basic operating system.

STRETCHING THE LIMITS

The IBM AT was introduced in 1984, sporting the spiffy new 80286. In 1986, the code phrase for the new protected mode operating system being developed by Microsoft and IBM for the 80286 was DOS 5. The skeptics who believed in DOS and its rich set of user applications were the first to develop DOS extenders.

Back in 1987, as an OS/2 disbeliever, I predicted that DOS extenders would likely have at least a five-year life span. The five years will soon be up, and the prospects for their continued existence seem brighter than ever. One surprising fact is that the four principal players at the time—Rational Systems, Ergo Computing (formerly A.I. Architects), Phar Lap Software, and IGC—have remained the same. Microsoft has now joined the club with the DOS extender it built into Windows 3 (standard and enhanced modes), as has Salford Software (from Great Britain), which bundles a DOS extender with its Fortran (and soon other language) compilers. These are marketed in the United States by OTG Systems. MetaWare, the first compiler vendor to support the 386 protected mode under DOS, still plays a major part in this market.

Some things may persist, but much has changed since the first versions of these products. The early 286 DOS extenders were able to use the existing 16-bit DOS compilers by supplying patches to their runtime libraries for the protected mode, but 386 compilers were limited. Now we have an abundance of tools for 386 development. Most DOS compilers and development tools come bundled with a DOS extender to free them from DOS's 640K memory limits. Even Microsoft has quietly slipped in its 286 DOS extender from Windows 3 (DOSX.EXE) with this summer's update of the C6.0a compiler. DOS 5 may add back 30 to 40K for an application, but DOS extenders add megabytes.

IT'S ALWAYS SOMETHING

With the introduction of Windows, a new set of problems and opportunities has arisen for the vendors of DOS extenders. Similar scenarios have occurred in the past. In 1987, Phar Lap Software and Quarterdeck Systems joined forces to develop the Virtual Control Program Interface (VCPI). This headed off the potential problem of memory managers (such as DESQview's QEMM and Qualitas's 386MAX) and DOS extenders fighting for control of the 80386 in protected mode.

Except for IGC's XAM, VCPI support was swiftly added to all DOS extenders and memory managers, eliminating the possible conflict between them. (IGC's XAM was based on running DOS in the virtual-8086 mode, which made implementing VCPI much more difficult.) The VCPI standard (completed in 1989) is based on the memory manager being the server and the DOS extender being the client. Both programs run at ring 0, so there's no chance to virtualize devices and no way to protect one application from another. VCPI works because the DOS-extender software and the memory-manager software cooperate.

Since the development of VCPI,

M. Steven Baker is the editor of Programmer's Journal *and a co-author of* Extending DOS, *published by Addison Wesley.*

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DOS extenders and memory managers have responded to the XMS API for managing extended memory above 1MB. More recently, the Virtual DMA Services (VDS) specification has also been supported. This specification is needed for some hardware boards (such as SCSI adapters and hard-disk controllers) that incorporate their own DMA chips on the board. VDS ensures that programs (commonly, device drivers, tape backup software, etc.) can lock memory and retrieve an actual physical address that will be put on the system bus for DMA access. Without some sort of well-defined protocol, it's possible that a memory manager, DOS extender, or multitasker might page out the target physical memory block during a transfer and substitute another logical chunk of memory.

Now Windows 3 has added the DOS Protected-Mode Interface (DPMI). DPMI is designed to allow DOS extended applications to run under any 386 operating system or control program that supports it. The DPMI specification is available from Intel (see vendor information). The first product to be released with support for DPMI, Windows 3 acts as a DPMI host. DPMI hosts have since been promised for IBM's OS/2 2.0 and from a number of 386/Unix vendors.

For both 286 and 386 DOS extenders, the exciting changes are based on incorporating code to allow them to operate as DPMI clients. Programs that incorporate the new DOS-extender versions are currently able to run under Windows 3 in a DOS box and will run under future versions of OS/2 2 and Unix/386, as well as on plain old DOS. If such a range of options sounds like a new lease on life, it's because it is.

THE EMPEROR'S NEW CLOTHES

First, I should mention that implementing DPMI clients in DOS extenders causes some headaches for their vendors. These products must incorporate support for a number of different extended memory APIs to cope with all possible situations:

- Bottom-up extended memory allocation (first used by VDISK.SYS)
- Hook INT 15h (function 88h) interrupt handler for top-down memory allocation
- VCPI used by 386 memory managers (EMS and XMS simulators)
- XMS drivers (HIMEM.SYS)
- DPMI

Of these five methods, DPMI is clearly the most complex to incorporate. This is exacerbated by the fact that the DPMI 0.9 specification supported in Windows 3 is missing some of the functions required to provide all the features available under the DOS extenders when running stand-alone on plain DOS. Also, these products are all designed to work with either the 0.9 or 1.0 version of DPMI. As yet, there's no DPMI 1.0 host available with which to test a DPMI DOS-extender client, so the big question is whether the vendors will have to revise their DPMI client code after a real DPMI 1.0 server becomes available.

DOS 5 may add back 30 to 40K for an application, but DOS extenders add megabytes.

LOOK THROUGH ANY WINDOW

Before we look at the DOS-stretching products, let's discuss the big incentive for all this feverish activity—namely, Windows 3. Although it may not be as friendly or consistent as the Mac OS, Windows 3 is the hot user interface in DOS town. And after all the years of bad-mouthing DOS extenders, Microsoft has gone ahead and incorporated one into their new Windows runtime. The DOS extender in Windows even supports both 286 and 386 programs. You won't find much information about this in the Windows SDK manuals, so I'll point out a few places to find some. Although the manuals never directly mention DPMI services or DOS extenders, Windows 3 supplies a standard INT 21h DOS-stretching interface to applications. The *Windows SDK Reference—Volume 1* briefly documents the calls **DOS3Call** (eventually issues an INT 21h to DOS) and **NetBIOSCall** (issues the NETBIOS interrupt 5Ch).

Because only registers are used for entry and return values, both calls must be made from assembly language. These two routines are exported from KERNEL.EXE and are not defined in any Windows **include** files. The manual also states that using **DOS3Call** is faster than an INT 21h, presumably because you use a call gate instead of going through the interrupt descriptor table (IDT). Windows 3 can be run in either real, standard (286 protected), or enhanced (386 protected) mode. In the two protected modes, Windows acts as a DOS extender and transfers these DOS calls to the real-mode DOS system in the lower 640K of memory. Nowhere in the manuals will you find a list of the DOS function calls supported by this mechanism. Microsoft publishes a five-page technical note that describes the supported DOS calls and DPMI functions. Although undocumented, other DOS INT *x* and ROM BIOS calls are also supported from the protected modes. In general, most INT calls are passed on to real-mode DOS by the Windows kernel. For illustration, do an INT 10h call from a Windows program and you'll get garbage on your screen. The vendors of DOS extenders have the choice of using the Windows DOS extender or using DPMI to work around Windows.

A number of other DOS-like file I/O functions are mentioned in the *Windows SDK Reference*. These include **GetDriveType, GetTempDrive, GetTempFileName, _lclose, _lcreate, _lseek, _lopen, _lread, _lwrite, Openfile,** and **SetHandleCount.** The purposes of these functions all correspond reasonably well with their names, except for **OpenFile,** which can create, open, or delete a file.

Exploring the main Windows SDK library with a good librarian (such as SLR's OPTLIB) will turn up an assortment of undocumented selectors, data variables, and functions. A few of the more interesting ones are **EnableDOS, DisableDOS, EnableKernel, DisableKernel, GlobalMasterHandle, OpenPathname, DeletePathname, GetLastDiskchange, NoHookDOSCall, KbdRst, FileCdr, DoSignal,** and **GetCurPid.** You'll also find some undocumented exported functions that are related to selector handling. Some of

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these are **GetTaskDS, PrestoChangoSelector, SelectorAccessRights, GetSelectorBase, SetSelectorBase, GetSelectorLimit, SetSelectorLimit,** and **AllocSelectortoArray.** Undocumented data selectors include __ROMBIOS, __0000H, __0040H (which doesn't point there), __A000H, __C000H, __D000H, __E000, __F000H, and _FFFE_FARFRAME. A slew of undocumented exported functions deal with spooling printed output and network functions. But the most intriguing of all are the undocumented functions **Death** and **Resurrection.**

STEPPING UP TO 32 BITS

Volume 2 of the *Windows SDK Reference* briefly discusses (in Appendix E) the WINMEM32.DLL, which can be used by Windows apps for 32-bit memory management. This DLL supplies a standard method for implementing a 32-bit flat memory model. The SDK documentation states that using these calls guarantees that your application will run with future Windows versions. WINMEM32 contains eight functions to enable accessing 32-bit memory from an application:

- **Global32Alloc** allocates a block of 32-bit memory
- **GlobalRealloc** changes the size of a 32-bit memory object
- **Global32Free** frees a 32-bit memory object
- **Global16PointerAlloc** converts a 32-bit pointer to a 16-bit far pointer alias
- **GlobalPointerFree** frees a 16-bit pointer alias
- **Global32CodeAlias** creates a code alias for a 32-bit memory object
- **Global32CodeAliasFree** frees a 32-bit code alias
- **GetWinMem32Version** returns the version of the DLL

The WINMEM32.DLL shipped with Windows SDK has a reputation for being buggy, and many developers have steered clear of it. For programmers, WINMEM32.DLL puts a pretty face on some DPMI calls. The original Windows 3 runtime had several bugs related to DPMI and real-mode programming, so Microsoft updated it in late 1990. If you have an old version of Windows (files dated 05-01-90), you should have it updated to version 3.0a.

DPMI is mentioned only in a short paragraph in a README file on one of the disks in the Windows Device Driver Kit, but it is part of Windows 3 in both standard and enhanced modes. One drawback to

LISTING 1

```
/* testdpmi.c - based on Intel 0.9 DPMI spec, use Microsoft C6 cl -AS */

#include <stdio.h>

unsigned short GoProtected();
unsigned short getdpmiInfo();

main()
{
    unsigned short regCS, regDS, regES, regSS, regSP;
    unsigned dpmiES, dpmiDI;
    unsigned short dpmiFlags, dpmiParas, dpmiCputype;

    struct {
        unsigned char minor;
        unsigned char major;
    }   dpmiVer;

    _asm mov    regCS,cs                ;store real mode CS
    _asm mov    regDS,ds                ; and DS for display

    printf("Operating in real mode with CS=%04xh DS=%04xh\n\n",
           regCS,regDS);

    if ( getdpmiInfo() ) {
        printf("A DPMI server was not found .., exiting\n");
        exit(1);
    }
    _asm {
        mov     dpmiES,es               ; also the DPMI entry point
        mov     dpmiDI,di               ; for later
        mov     dpmiVer,dx              ; Also the DPMI version
        mov     dpmiCputype,cl          ; the Processor type
        mov     dpmiFlags,bx            ; if BX bit 0=1, 32-bit apps ok
        mov     dpmiParas,si            ; Private data area required by
                                        ;   DOS extender in paragraphs
    }
    printf("DPMI version = %d.%d  entry point = %04x:%04xh\n",
                dpmiVer.major, dpmiVer.minor, dpmiES,dpmiDI);
    printf("Processor type is an 80%d86 and the dpmiFlags are %04xh\n",
        dpmiCputype, dpmiFlags);
    if (dpmiFlags && 1)
        printf("32-bit applications are supported\n");
    else
        printf("32-bit applications are not supported\n");

    printf("DPMI requires %04xh paragraphs of private data area\n\n",
           dpmiParas);

    if ( GoProtected() ) {
        printf("Not able to switch to protected mode or malloc failed\n");
        exit(1);
    }
    _asm {
        mov     regCS,cs                ;store registers we got from
        mov     regDS,ds                ; protected mode
        mov     regES,es
        mov     regSS,ss
        mov     regSP,sp
    }
    printf("We're in DPMI protected mode now with registers set as\n");
    printf("CS=%04xh  DS=%04xh ES=%04xh  SS=%04xh  SP=%04xh\n",
           regCS, regDS, regES, regSS, regSP);

    _asm mov    ah,4ch              ;the only documented way out
    _asm int    21h                 ; from DPMI is to use this DOS exit
}

unsigned short getdpmiInfo(void)
{
    _asm    mov ax,1687h
    _asm    int 2fh
}

unsigned short GoProtected(void)
{
    void far *dpmi_entry;

    _asm {
        mov     ax,1687h                ; just get the registers again
        int     2fh                     ;  it's easier
        or      ax,ax                   ; we should get a zero again
        jnz     dpmi_error

        mov     word ptr dpmi_entry,di  ;store the entry address
        mov     word ptr dpmi_entry+2,es
        or      si,si                   ;is memory needed ?
        jz      call_dpmi

        mov     bx,si                   ; allocate memory for DPMI
        mov     ah,48h                  ; private area
        int     21h
        jc      dpmi_error

    call_dpmi:
        mov     es,ax               ;pass segment of data area
        mov     ax,0                ;indicate we are a 16-bit app
        call    dpmi_entry          ;switch to protected mode
        xor     ax,ax               ;signal success
    }
    dpmi_error: ;
}
```


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the Windows 3 implementation of DPMI is that it's available to both Windows and DOS applications in the enhanced mode, but available only to Windows applications in the standard (286) mode. In standard mode, Windows doesn't support a call for DOS apps to find the entry point of the DPMI host. So it's tough luck, folks.

Using the DOS extender supplied with Windows 3, it is now possible to write 286 and 386 apps that run under Windows and can access lots of memory. You may, however, need access to real-mode memory, interrupt vectors, or special services that are not openly provided by Windows: they may be there using DPMI, but it takes a good bit of work to make them function. Also, such applications will run *only* under Windows or some other DPMI host.

If you want to ship a single executable that will run under DOS or Windows, the DOS-extender vendors have the solution. Most of these products have been around in some form for four years. And over this time, their vendors have added a number of features that facilitate creating extended-DOS programs. Most of these products are also well supported by compilers and other development tools. Let's begin our tour with the new 286 DOS extenders.

PHAR LAP RIDES AGAIN

Earlier this year, Phar Lap software released the only truly new product in this lineup—the 286|DOS-Extender SDK ($495). Its name may not earn many points for creativity, but in other ways this product is a winning contender. It can execute as a DPMI client, so it is compatible with the DPMI server as implemented in Windows 3. The original DOS extenders (both 286 and 386) have supported the standard INT 21h DOS interface, but in protected mode. The Phar Lap 286|DOS-Extender breaks with tradition by supporting two programming interfaces: the DOS interrupt interface and the call-stack-based interface of OS/2 (VIO calls only—no Presentation Manager here). Although this sounds like more work than just supporting the DOS INT 21h mechanism, it's actually a much simpler approach. I'll outline why below.

The 286|DOS-extender is designed to work with Microsoft C versions 5.1, 6.0, and 6.0a. For the time being, that's it. If your preferred development environment is something else—such as Borland or Zortech C++, Turbo Pascal, a different C compiler (from Watcom, MetaWare, or JPI), or another language—well, this product as it now stands won't cut it for you.

In spite of these limitations, Phar Lap did derive a nice side benefit by having their runtime support the OS/2 character-mode API. They already have a windowing symbolic debugger available in Microsoft's CVP (OS/2 protected-mode CodeView debugger). RUN286 (the loader for 286 DOS-extender applications) can be used to execute most of the Microsoft C OS/2 (protected-mode) development tools under DOS on a 286 or 386 machine with extended memory. The Phar Lap tools also support DLLs, just as OS/2 does. In fact, Phar Lap ships a number of DLLs with the product, including support for named pipes, session manager calls, queues, and threads. They also include patch files for the Microsoft C OS/2 libraries for the three supported compiler versions. These add some functions that aren't available in OS/2, such as an **int86** function, and they also patch some other OS/2 routines. The library additions also provide access to the Phar Lap API (PHAPI.LIB), with support functions to ease the transition to the protected mode.

The WINMEM32.DLL shipped with Windows SDK has a reputation for being buggy, and many developers have steered clear of it.

The product comes with three perfect-bound manuals: the *Release Notes*, a *Developer's Guide*, and a *Reference Manual*. The *Developer's Guide* provides a number of examples (also included on disk) that illustrate features such as hooking interrupts, mixing real- and protected-mode code, and accessing DDE. The SDK can be used for development. An unlimited runtime license for bundling RUN286 with your application starts at $995 (some restrictions apply).

Under Windows 3 on a 386/486 (in enhanced mode only), 286|DOS-Extender acts as a DPMI client and supports virtual memory (or, more accurately, the Windows 3 enhanced mode supports virtual memory). When it's running stand-alone on a 286/386, only physical memory is available. Under Windows 3 in standard mode (as when running on a 286), an application is limited to less than the 640K that DOS provides. For more memory, an XMS driver (HIMEM.SYS) must be installed, and a PIF file must be created for your application that makes XMS memory available. Otherwise, the DOS extender is running in a limited DOS box. Under standard mode, 286|DOS-Extender does not offer virtual memory.

WINDOW MODES AND DPMI

Unlike DOS apps, Windows apps *do* have access to DPMI in the standard mode, allowing more memory space and machine control. The reason for this difference is clear enough: Windows does not provide access to the DPMI entry point from a DOS app in standard mode; to support DPMI in a DOS box would have reduced the size of the DOS box by 30 to 40K.

Listing 1 is a short program inspired by the 0.9 DPMI specification. It tests for the presence of DPMI, reports statistics on the DPMI host, switches into the protected mode, and then exits. You can test this code on machines running enhanced-mode Windows on a 386/486 or forced into standard mode with WIN/S on a 386; or you can run it on a 286. The Windows 3 DPMI host does test and return the proper CPU type (presumably, it uses self-modifying code and the differing lengths of the prefetch queue). The DPMI entry point is always at selector F000h, but the offset varies by machine and invocation.

THE OS/2 API

As mentioned above, Phar Lap took the easy path by supporting two APIs. If they had supported only the DOS interrupt

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21h API, Phar Lap developers would have been busy testing, disassembling, and patching the DOS (real-mode) C runtime libraries so that they would execute properly in the protected mode. And every minor compiler and library update would have required this kind of effort. This is precisely what the other 286 DOS-extender vendors (Rational and Ergo) have been doing for the past four years. Of course, these other products support many more compilers and development environments.

By adding the OS/2 API, Phar Lap was guaranteed code generation, as well as runtime libraries that should run, mostly without change, in the protected mode. Even here they hit a few snags, and there are still some library patches. For example, QuickHelp, PWEB (the workbench), the Resource compiler, and a few other OS/2 executables do not run under RUN286. The new Microsoft Profiler (OS/2 version) also makes a few **DOSPTrace** calls not currently supported by RUN286, but they will be in an update. All in all, the 286|DOS-Extender is definitely an interesting product.

ERGO EDU-16 FOR DPMI

Ergo Computing is about to ship its latest DOS extender, EDU-16 (Ergo DPMI Utilities for 16-bit applications). EDU-16, a rewrite from the ground up, takes full advantage of the DPMI interface under Windows; for non-Windows environments, Ergo still offers its OS/286 and OS/386 DOS extenders. EDU-16 is the only DOS extender that can function as a DPMI host *or* a client, so you can run my little DPMI inquiry program under EDU-16 stand-alone, and it'll return information on Ergo's implementation of DPMI. When running an application under Windows in the enhanced mode, EDU-16 uses the Windows DOS extender; under DOS, it uses the Ergo kernel.

The EDU-16 development kit ($495) includes the DOS-extender kernel, replacement **obj** files for various popular compilers, a symbolic debugger, a program loader, and example code. The kit supports development with Borland C++, Microsoft C 5.1 and 6, and Fortran 5. Borland's BGI is also supported.

Although EDU-16 runs segmented executables (as do Windows and OS/2), it supports the familiar DOS (INT 21h) and ROM BIOS interfaces. EDU-16 includes a library of DPMI functions callable from C or C++ and supports the creation of DLLs that can be marked for either real- or protected-mode operation. The kit is particularly attractive for Borland C++ users, because the Borland IDE, including the IDE linker, can be used for development.

Running under Windows in standard mode, EDU-16 has the same limitations as the other products. Virtual memory is available in enhanced mode. If your application is stand-alone and won't be running under Windows, Ergo's other DOS extenders (OS/286 and OS/386) are available with virtual memory options.

When you're ready to ship your product, you buy an unlimited redistribution license for a reasonable, one-time fee ($500), and Ergo supplies utilities to bind the EDU-16 kernel with your application for distribution. Ergo is working on a 386 version of this product (EDU-32) for future release.

RATIONAL'S DOS/16M

Rational Systems' DOS/16M 286 DOS extender has been around for years. Being bundled with Lotus probably gives it more users than any other DOS extender. The current version (v3.95) supports DPMI, so it can also run under Windows 3. DPMI 0.9 and 1.0 are both supported, but without a DPMI 1.0 host, Rational is reluctant to call it 1.0-compatible. DOS/16M is a close parallel of the INT 21h API of DOS. Its support of many extended functions makes it easier to move to the protected mode.

Late this spring, Rational released Oxygen, a product for Microsoft C 6 that binds a 16-bit OS/2 API DOS extender to the C 6 OS/2 executables so they can run under DOS. This keeps memory-hungry C 6 from running out of heap space under DOS. They had this OS/2 technology in house for about 18 months. Unfortunately for Rational, this release coincided with Microsoft's bundling of its Windows DOS extender with C 6.0ax.

When running under its own DOS extender, DOS/16M supports virtual memory by swapping out segments to disk. Under Windows 3, it acts as a DPMI client and runs in a DOS box. Under Windows 3 enhanced mode,

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large memory spaces and virtual memory are available. If it is run under Windows standard mode, the Windows 3 limitation discussed above applies.

DOS/16M SDK ($5,000) supports a number of compilers as development environments: Microsoft's C, Fortran, and Pascal; IBM's C/2 and Pascal; Borland's Turbo C; Watcom C, Lattice C, Logitech Modula 2, JPI Modula 2, and Zortech C++. For these compilers, replacement object modules are provided for their runtime libraries. The supported compiler is often not the latest version. DOS/16M is strong on national language support and protected-mode TSRs. Rational supplies a Windows virtual device driver to allow TSRs developed with DOS/16M to work properly under Windows. The SDK also includes a protected-mode linker and symbolic debugger for DOS-extender apps.

During testing, you can use Rational's loader, but when your application is complete, the development kit includes various source and **obj** modules to splice the loader to your application. DOS/16M is intended to be an OEM product, and its price reflects this fact.

HAPPENINGS AT THE HIGH END

The real action in the DOS-extender world is at the high end, and the action is shifting to the compiler vendors. For much of this material I am under nondisclosure agreements and can only comment on generally available information.

Although Intel has been marketing its Intel 386/486 C Code Builder Kit ($695), it has been withholding the product from reviewers. You can still buy it from several mail-order suppliers, though. The Intel kit includes a 386 C compiler (developed in-house), a linker, a symbolic debugger, a make utility (the excellent Opus Make), and a new version of the IGC DOS extender.

The DOS extender supports DPMI, so it runs under Windows but does *not* currently support VCPI. You can't run the DOS extender under QEMM, 386-MAX, or other memory managers, which is a drawback. This is due to the design of the IGC DOS extender: it's the only product that runs DOS in the virtual-8086 mode instead of switching to real mode.

The Intel kit is easy to use, and the C compiler library is Microsoft-compatible. When you run the compiler driver (icc), it automatically links your application and produces a protected-mode executable. It comes with a 387 emulation library, so a math coprocessor is not required. The enticement for small developers is that there is no charge for bundling the DOS extender runtime with your product; one box price gets everything.

But the current version is not without flaws. First, it's the only DOS extender that is incompatible with VCPI. When running under Windows 3 DPMI, the DOS extender has some nasty bugs related to Control-C behavior and virtual memory. The C compiler fails some ANSI validation tests, including the Plum Hall sampler. Intel is working to fix these problems.

The exciting news is that Silicon Valley Software (SVS) will also bundle the Intel (IGC) DOS extender with its fine line of C, Fortran, and Pascal compilers—again, with no runtime fee and priced reasonably. The Pascal and C compilers are priced at $325, and the Fortran compiler is $395. My experience with SVS compilers has been very favorable. They generate very fast code, particularly for numerics. This combination is something to watch for.

Phar Lap's v4.0 of 386|DOS Extender now supports DPMI. You can use this DOS extender for creating applications that will run stand-alone or under Windows 3 enhanced mode. This does *not* mean that they will be Windows apps, but they can execute in a Windows 3 DOS box.

Rational Systems is poised to release its first 386 DOS extender, DOS/4G. Like DOS/16M, DOS/4G is DPMI-compatible, and it comes with Rational's protected-mode linker and debugger. It supports the DOS INT 21h API and works with MetaWare's High C/386 and Watcom's C/386, as well as with Microsoft's OS/2 2.0 C32 compiler.

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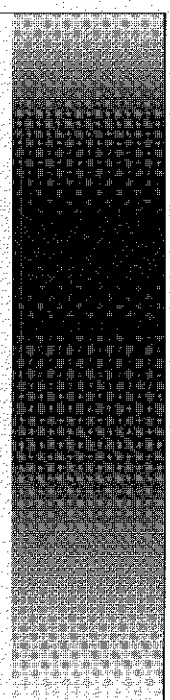

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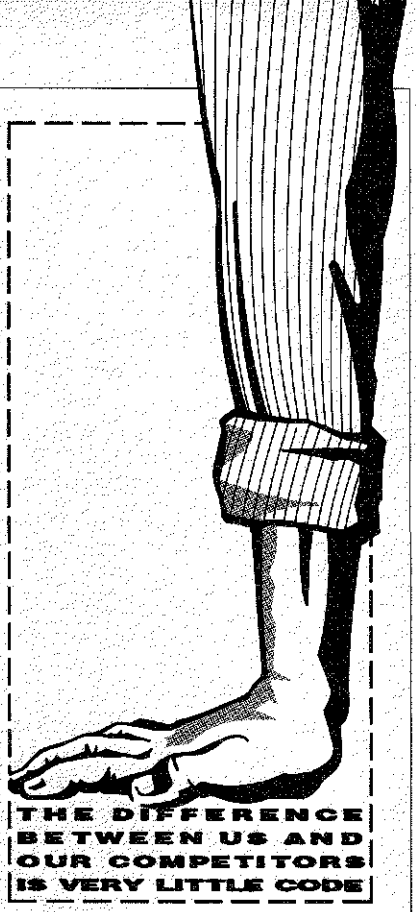

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Salford Software's new WDBOS v2.60 DOS extender now supports DPMI. This British import is bundled with OTG Fortran compilers and with several other development tools from Great Britain. A soon-to-be-released 386 Pascal from Sheffield also uses WDBOS. WDBOS is a TSR with a small DOS footprint; its library of routines resides in protected mode. The runtime libraries for the OTG 386/486 Fortran compilers actually reside in the WDBOS DOS extender. Pricing for the earlier DBOS unlimited runtimes is $495.

MicroWay has released a very interesting product for 386 developers. NDPWIN, designed for versions of its 386/486 compilers (C, C++, Pascal, and Fortran), runs under Windows 3 and allows you to develop applications that run under Windows 3. NDPWIN is a custom loader that runs as a Windows application. This in turn sets up a 386 flat model. The NDPWIN language libraries interface directly both with the WINMEM32 DLL supplied with the Windows SDK and with the low-level Windows 3 I/O functions (**OpenFile, _lread,** etc). Again, these are not true Windows apps; they're 386 character-based apps that run as Windows apps under Windows 3 enhanced mode. No separate DOS extender is necessary for redistribution. (By the way, *PJ* contributor Mark Barrenechea has been named vice-president for language development at MicroWay.)

TRUE GUI APPS

So far I've talked about running 286 or 386 DOS-extender applications under Windows 3. This is a convenience to users who prefer Windows as their multitasker or menu interface to DOS. But the real challenge is developing true 32-bit Windows GUI applications that can support the full Windows API. Both Watcom and MetaWare are about to release products that accomplish that feat. Rational has also announced a similar product called BigWin, which is designed to link with several 386 C compilers.

The Microsoft Windows API is a large, 16-bit interface, and a number of functions issue call-backs to your code. Watcom and MetaWare have had to build a glue layer (they both call

See Baker, page 90

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Managing memory

The "whys and wherefores" of the Macintosh Memory Manager

By Brett Glass

Most early microcomputers simply did not have memory management. CP/M-80 systems, for example, ran almost exclusively in a simple, flat address space consisting of 64K or less of RAM—all visible to the processor at once. (Some CP/M computers did provide bank-switching capability. It was used most often for "phantom" boot ROM or to hold the operating system so that the Transient Program Area could be as large as possible.)

By contrast, nearly all the latest and most powerful microprocessors (e.g., the 80486 and 68030) have memory management units (MMUs) built in, so they can handle mapping, paging, and virtual memory with little or no additional hardware.

The Macintosh Memory Manager, introduced with the original Macintosh computer in 1984, represents an intermediate step between these worlds: a set of operating system routines and programming conventions that provide flexible, relatively efficient memory allocation in a system that lacks hardware memory mapping or an MMU. This article delves into the "whys and wherefores" of the Macintosh Memory Manager.

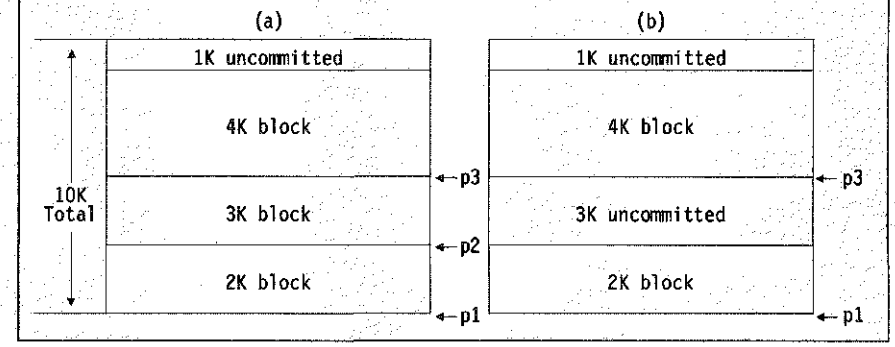
WHY A MEMORY MANAGER?

If the CP/M-80, Apple II, IBM PC, and other popular systems of the day didn't require sophisticated memory management software, why did the Macintosh? One reason was economy. To maintain its fabled 50% gross margin on hardware and still sell a computer that users could afford, Apple could put only 128K of RAM into the Macintosh—in retrospect, too little to handle the requirements of the operating system, GUI, and application software. The basic system resources—including fonts, code, bitmaps, and other large data structures—could easily overflow memory if they were all present at once. What's more, code for the 68000—the CPU at the heart of the Macintosh—consumes more space per operation than equivalent code on many other CISC processors. This made the Mac's memory crunch far more acute than on some of its less ambitious character-based contemporaries, which at the time typically sold with 256K of RAM.

A hardware MMU similar to that on the early Sun workstations (a clever design that came out around the same time) would have been too expensive.

Brett Glass is a freelance programmer, author, hardware designer, and perpetual student residing in Palo Alto, California. Brett was one of the original architects of the IEEE 802.5 Token Ring LAN, and he co-authored Living Videotext's ThinkTank 2.0. Brett earned his MSEE from Stanford University and his BSEE from the Case Institute of Technology. He can be reached as [72267,3673] on CompuServe or as "rogue@well.sf.ca.us" on USENET and the Internet.

FIGURE 1: Simple 10K heap



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Macintosh opted to perform memory management in software instead and chose a flat physical address space—the simplest and cheapest to implement. These factors all made an efficient memory manager vital to the success of the Macintosh.

FRAGMENTATION WOES

Before we examine the specifics of the Macintosh Memory Manager, let's look at the techniques used for managing a simple *heap*—a pool of dynamically allocated memory. Suppose we start with a contiguous block of uncommitted RAM (a *heap zone*, in Apple parlance) 10K in size. An application begins to request memory, asking for blocks of 2K, 3K, and 4K (Figure 1).

In each case, a call such as **new** or **malloc** (depending on the language) returns a pointer to a block of memory the application can use. Most heap implementations use a *first fit* algorithm to find the memory to be allocated; they start at one end of the heap zone and allocate the requested space from the first chunk of uncommitted space that's larger than or equal to the required size.

Figure 1b shows what happens if the 3K block is freed, leaving 4K of available space. There's now 4K available, but it's discontiguous; a request for a 4K block of RAM would fail. This phenomenon, called *fragmentation*, can be costly. In a system that's been running for a long time, large amounts of memory can be wasted, because small fragments of memory are caught between other blocks.

The example is an oversimplification, of course; we haven't shown the headers and trailers that most heap managers attach to blocks. But the problem of fragmentation is endemic to heaps in general.

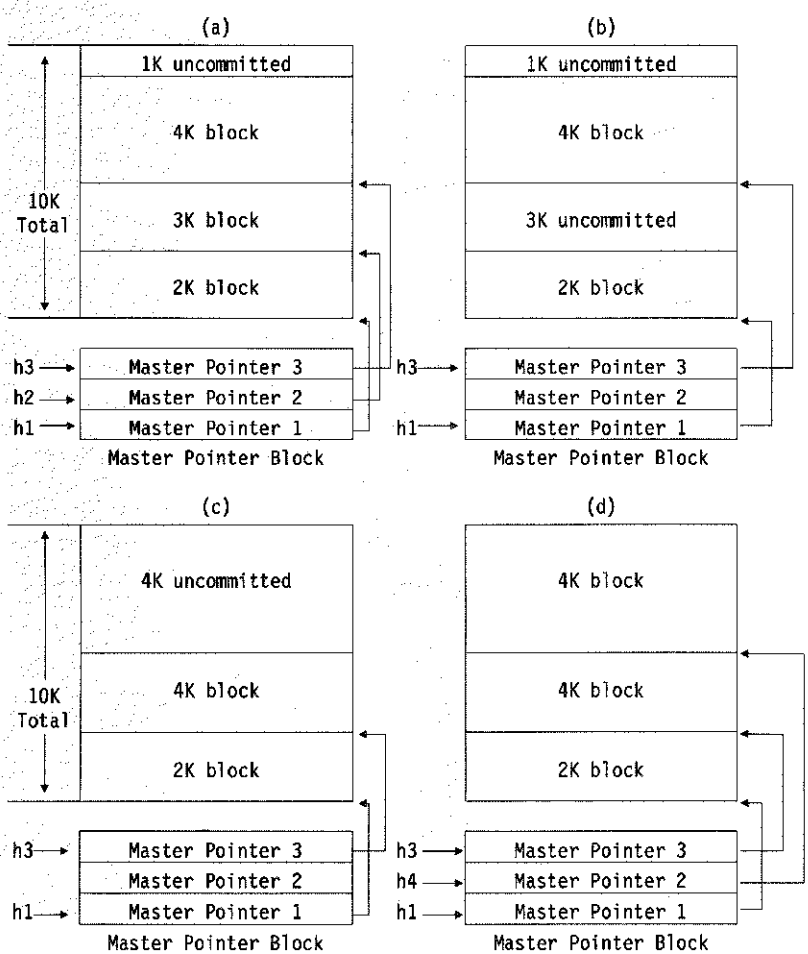
An MMU enables a system to handle fragmentation easily. Logical addresses can be mapped to physical addresses, so discontiguous blocks of RAM can "look" contiguous to an application (subject to granularity constraints). But the Macintosh, with its unaided 68000 CPU, couldn't take this approach. What about consolidating the contents of the discontiguous blocks by moving them around physically? Unfortunately, although the 68000 can do this, there's not any way to update all the application's pointers to point to the correct places after the move. And failure to do so would, as you might expect, result in dangling pointers and almost certain disaster.

Because neither of these approaches was feasible, the Macintosh took a third: a technique called *double indirection*. An application that requests a block of memory is given a data object called a *handle* instead of a pointer to the memory. A handle is a pointer that points to another pointer, called a *master pointer*, which in turn points to the memory.

How does this tactic help to solve fragmentation problems? Figure 2 shows the scenario described above, but adds double indirection. Note that it's possible to change a master pointer without leaving any of the application's handles "dangling." This means that the memory manager can compact the heap by moving blocks; it only has to keep the master pointers current.

This, in essence, is the way the Macintosh Memory Manager allocates relocatable blocks. (We'll come back to a few additional housekeeping details.) When the application calls the memory manager's **NewHandle** routine, it reserves memory, sets up a master pointer, and returns a handle (the address of the master pointer).

FIGURE 2: Heap with double indirection



USING THE MEMORY MANAGER

With the power of double indirection comes responsibility: the programmer must know and understand the conventions that allow handles to work properly.

Suppose that, while programming the Macintosh, you wanted to allocate space on the heap for an integer variable. (In practice, you'd probably

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want to allocate something larger, but let's keep things simple.) You might reserve the space in the following way:

```
type
  IntPtr = ^Integer;    {A pointer to an integer  }
  IntHandle = ^IntPtr;  {A handle (a pointer to   }
                        {a pointer) to an integer }
var
  i : IntHandle; {Variable to hold the handle     }
                 {for the allocated memory        }
...
  i := IntHandle(NewHandle(SizeOf(Integer)));
```

NewHandle takes a long integer argument and returns a value of the type **Handle.** (**Handle** is defined in the Macintosh headers as a pointer to a pointer to a signed byte; you must use a typecast to assign the value to a handle that references something else.) If sufficient memory is not available, the handle is NIL; otherwise, it can be dereferenced twice to get at the allocated memory.

Note the use of **SizeOf** and a typecast in the example. **SizeOf,** which returns the size of an object of a given type in bytes, is a good way of making sure you allocate the right amount of space. It's necessary to cast the result of **NewHandle** to the type **IntHandle** to tell the compiler that it's OK to perform the assignment.

To access the variable you created, simply dereference the handle twice, like this:

```
i^^ := 2;     {Assign a value to a heap variable}
Writeln(i^^) {Then print its value}
```

In an ideal world, each application would perform a double dereferencing operation on a handle every time it accessed data on the heap. This would take changes in the master pointer into account at all times. In real applications, however, speed definitely matters. The extra memory reference needed to fetch the master pointer would slow things down enormously—a burden that high-performance software can ill afford.

At first glance, it appears that you might be able to speed things up by dereferencing the handle once at the beginning of the routine and again each time you used the variable, as follows:

```
var
  masterPointerCopy: IntPtr; {Copy of a master  }
                             {pointer to an integer }
...
masterPointerCopy := I^;  {Dereference the      }
          {handle once at the start to get a    }
          {copy of the master pointer           }
...
masterPointerCopy^ := 2; {Defererence again when}
                         {using the variable    }
```

But this technique can be dangerous. Suppose that, between the first and second assignments above, the operating system compacted the heap and updated the actual master pointer. The variable **masterPointerCopy** would not be updated and would no longer point to the correct place in memory; the program would therefore generate erroneous results.

For this reason, the Macintosh provides routines that "lock" a block of memory—that is, they prevent the memory manager from moving it and

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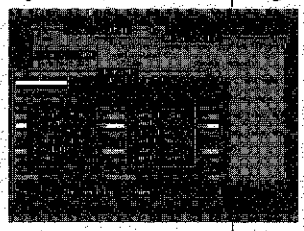

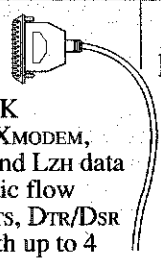

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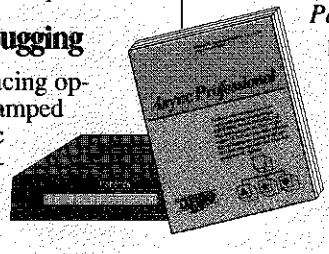

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changing its master pointer. The call **HLock(i)**, made before the master pointer was copied, would ensure that the block would not be moved. The call **HUnlock(i)** would let the block be moved once again.

Locking a block can keep the memory manager from fully compacting the heap. For instance, if the 4K block in Figure 2b had been locked, the compaction process could not have freed up enough memory to honor the next request for memory.

If an application needs a chunk of memory for a quick calculation, it can allocate a nonrelocatable block, do its work, and then deallocate the block right away.

When dealing with handles, you must be careful of language constructs that implicitly dereference them. For instance, an efficient compiler, given the Pascal statement

```
with theHandle^^ do
  begin
  ...
  end;
```

(where **theHandle** is used to access a record variable), will generate code that dereferences the handle, saves a copy of the result in an address register, and then uses that copy plus an offset to access each field of the record. To allow the compiler to do this with impunity, make sure that the handle is locked while the **with** statement is executed.

PURGEABLE BLOCKS

As mentioned above, the Macintosh operating system and applications frequently use *resources*—chunks of code and data (such as fonts) that are loaded from disk when needed. If all this data needed to be in RAM at once, little (if any) memory would be left for other things. Fortunately, because copies of these data structures reside on the disk, no information is lost if they're removed, or purged, from memory—freeing the space they occupied—to honor an allocation request. A heap block that contains such expendable data is called *purgeable*.

The memory manager purges a block from memory only as a last resort—that is, when compacting or expanding the heap space won't work. When the memory manager purges a block from memory, it sets the master pointer for that block to NIL. When the application program or the operating system can see that this has occurred (that is, that the handle is *empty*, in Macintosh parlance), it can ask the memory manager to reallocate some space for that handle using the **ReallocHandle** procedure; the program can then reload the resource.

For safety and convenience, all blocks on the heap start out unpurgeable. **HPurge** makes a handle purgeable, and **HNoPurge** reverses the process. A program can force a block to be purged by calling **EmptyHandle** with the handle as a parameter.

NONRELOCATABLE BLOCKS

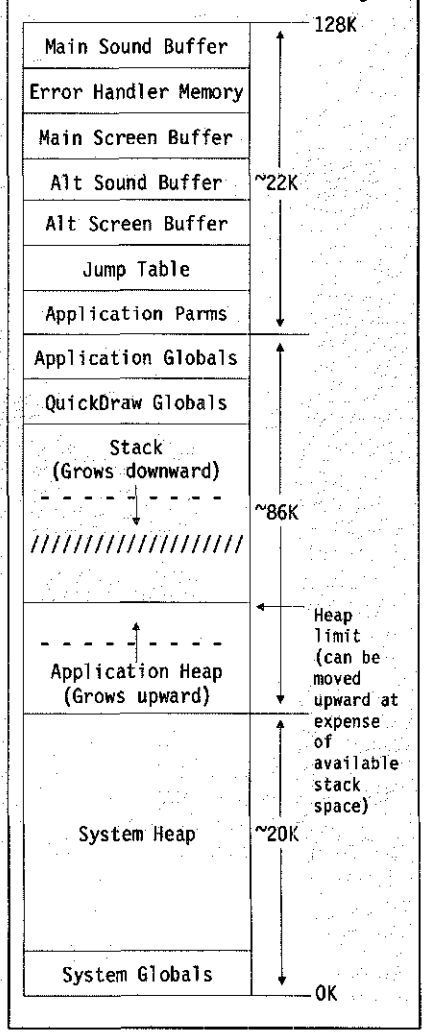
If an application wants to allocate some memory for especially fast access, it can ask the memory manager to allocate nonrelocatable blocks, as in a simple heap. These blocks are allocated via pointers that point directly to them, rather than via handles; they do not have master pointers associated with them. The function that allocates a nonrelocatable block is **NewPtr**.

Like locked blocks, nonrelocatable blocks can't be moved and may cause fragmentation. There are several ways to minimize this problem. If an application reserves its nonrelocatable blocks at the start of execution, before asking for any relocatable ones, the nonrelocatable blocks will be allocated contiguously at the bottom of the heap. No fragmentation occurs unless one of these blocks is subsequently freed. This approach is ideal when the memory will be used throughout the program's lifetime.

Master pointers always reside in nonrelocatable heap blocks. In the Mac's *application heap* (the heap zone your application usually uses), each such block—called a *master pointer block*—contains 64 pointers. This is exactly the kind of block to reserve early if you think you might need it. Why? Although the memory manager can create master pointers automatically at any time, it may cause fragmentation when it creates new, nonrelocatable master pointer blocks. Therefore, all but the most trivial applications should call the procedure **MoreMasters** one or more times upon start-up. Each call creates an additional 64 master pointers for use by the memory manager.

Nonrelocatable blocks need not be allocated only at launch time. If an application needs a chunk of memory for a quick calculation, it can allocate a nonrelocatable block, do its work, and

FIGURE 3: "Classic" Macintosh RAM layout



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then deallocate the block right away. This technique is equivalent to creating a relocatable block and locking it, but it's much more efficient: the system doesn't have to set up a master pointer, and the program doesn't have to explicitly lock and dereference a handle.

THE BIG PICTURE

Figure 3 shows how RAM was used in the original 128K Macintosh (other members of the Macintosh family are similar). Note that there are two heap zones: the application heap and the system heap. Each is usually used for a specific set of functions, and most applications use only the application heap; however, they can use the system heap if necessary.

When a program is launched on the Macintosh, a chunk of memory is allocated to hold its stack and its application heap. The stack grows toward lower addresses, and the application heap—initially given an upper limit by the operating system—can be grown toward higher addresses by raising the limit. A low-level operating system routine checks the two periodically to make sure they stay a safe distance apart.

Under MultiFinder (see below), things are a little more complex. Each application has its own stack and its own application heap, and they don't start at opposite ends of free memory. But the essential concepts are the same in all cases.

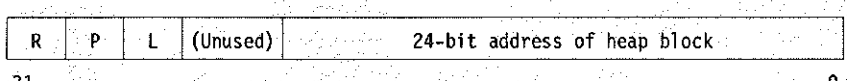
KEYS TO COMPATIBILITY

As the Macintosh architecture grows and changes, fewer and fewer assumptions can be made about the internals of the system. Assumptions can make programs fail unexpectedly, and sometimes catastrophically.

One source of problems for some of the Macintosh applications was the advent of MultiFinder, Apple's cooperative multitasking environment. In this environment, a program could no longer assume that it "owned" the machine—now it needed to share it with other applications.

Some of the new rules invalidated the tactics that had been used by certain applications to manage memory. For instance, a program couldn't plan its memory use by "scoping out" the machine's resources to find out how much memory was there. (If it did so, another application might not be able to run or might take some of the available memory without warning.) Instead, an application could specify only the minimum it needed to run—and the maximum it would ever want. Likewise, it became unwise for an application to use the system heap for its own storage, especially nonrelocatable storage. Doing so could clutter up memory that was needed to serve all the programs on the machine.

FIGURE 4: A master pointer in the original Macintosh



R = Resource bit (1 if block is a resource)
P = Purge bit (1 if block is purgeable)
L = Lock bit (1 if block is locked)

32-BIT CLEANLINESS

Another key to compatibility is making code "32-bit clean"—that is, using the upper byte of an address only for addressing. The reason is historical: the 68000 microprocessor, released in 1981, faced limits on package size, chip size, and power consumption that prevented it from allowing users access to 32 address lines. Only the 24 least significant bits of an address left the chip, so the upper byte of a pointer could be used for other things.

Later processors in the 68000 family remedied this shortcoming; the 68020 had a full 32-bit address bus. But the Macintosh ROMs had already been coded to place flag bits in the highest byte of many internal pointers, and the memory manager was among the biggest culprits.

Figure 4 shows the layout of a master pointer as implemented in the original Macintosh. Note that the uppermost byte contains three flags: the *resource bit*, the *purge bit*, and the *lock bit*. The resource bit is set by the Resource Manager to mark a block containing a resource. The lock bit is set if the block is locked, and the purge bit is set if the block is purgeable.

The Macintosh designers had anticipated the possibility of moving to processors with 32-bit addressing, and they provided routines (such as **HLock, HUnlock, HPurge,** and **HNoPurge**) to manipulate these flags. This, they reasoned, would allow them to move the flag bits to some other location in the future. But early copies of *Inside Macintosh* documented the exact locations of the flags and even provided assembly language symbols for them, encouraging programmers to save a system call and manipulate the flags themselves.

Because the original memory manager—along with many application programs—used the upper bytes of pointers in this and similar ways, the Macintosh II hardware was set up to mask the high byte of every address unless a specific bit in the Versatile Interface Adapter (VIA) chip was turned on. (Ironically, this is the same approach IBM took in the IBM PC/AT, where the A20 address line could be disabled to make the 80286 look more like an 8088.) But the Mac II's physical (and logical) address space was still limited to 16MB, except in device drivers and some other system code.

APPLE COMES CLEAN

With System 7.0, Apple has at last renounced its "unclean" ways. System 7 moves the flags out of each master pointer, and a systemwide option allows programs to use a full 32-bit address space. Unfortunately, on some of the older Macs—the II, IIx, IIcx, and SE 30—the ROMs themselves still aren't 32-bit clean. On these machines, using System 7 doesn't give you the option of 32-bit mode.

Fortunately, a company called Connectix has a workaround. For $169 or less, you can buy an operating system extension called Mode32. The extension patches around parts of the older ROMs and lets those systems enter

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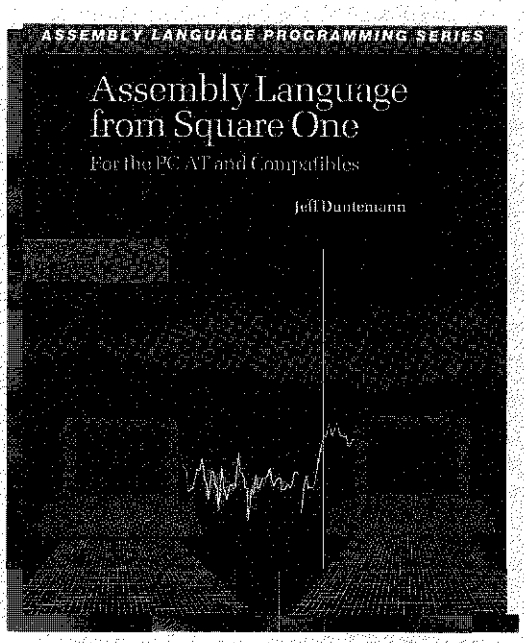

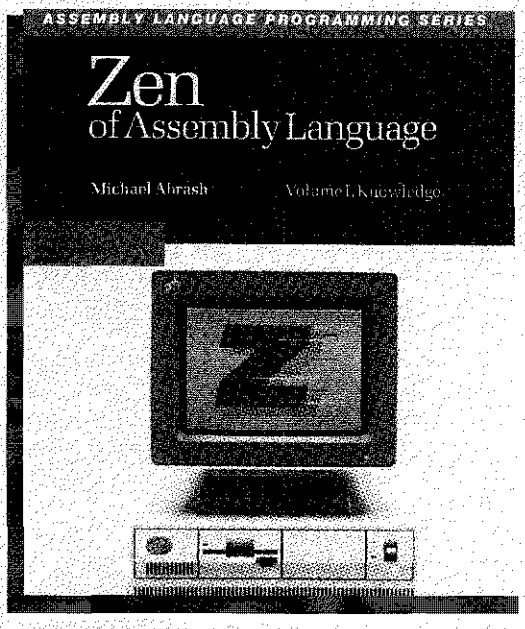

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32-bit mode. The Mac's control panel lets you go back to 24-bit mode for the few applications that don't work with 32-bit mode.

LET'S GET VIRTUAL

System 7 also provides *demand-paged virtual memory* on processors that support it, using either an external MMU (the 68851) or internal MMUs (the 68030 and 68040). Before System 7 shipped this spring, the only way to get virtual memory was to buy a program called Virtual, from Connectix. While System 7 was still vaporware, this company forged ahead with a utility that let users enjoy the benefits of virtual memory (it's still useful if you're running an earlier version of the Mac operating system). Also, unlike System 7, Virtual provides virtual memory on the 68030 accelerator boards that fit inside the Mac Plus, SE, and Classic.

Virtual is an *init*—a utility that loads beneath the Macintosh system software at boot time. The OS and applications can't tell that anything has changed, but they can now "see" up to 13.75MB of RAM in the machine. Virtual uses the MMU's paging unit to swap data to and from disk as needed, keeping only the most recently used data in physical RAM. (This is often called a *least recently used* [LRU] algorithm, because it picks data that hasn't been accessed for a while to move to disk.) Code and data are swapped in 4K chunks called *pages*; if the program attempts to access something that's not in physical RAM, a *page fault* occurs and special code brings it in from the disk.

VIRTUAL IS ITS OWN REWARD

An obvious advantage of virtual memory is that programs that once ran out of memory will now be able to execute—albeit more slowly. Even if an application worked adequately before, it may work more smoothly with virtual memory.

How can this be? One reason is that the LRU algorithm frees the programmer from a tricky task: deciding which parts of a program should be in memory at a given time. On the original Macintosh, programmers had to break their programs up into segments and use a part of the Macintosh OS called the *segment loader* to control which ones were in RAM at any given time. Unfortunately, there were so many factors to consider (such as sizes of fonts and system resources, desk accessories, the state of the Clipboard, the amount of available RAM, and possible commands the user might invoke) that programmers often chose unwisely and inadvertently slowed things down instead of speeding them up.

The LRU algorithm frees the programmer from a tricky task: deciding which parts of a program should be in memory at a given time.

An LRU algorithm avoids this problem by using the program's recent history to determine which parts of memory are least likely to be needed in the future. The programmer can still use the Segment Loader to provide "prescience"—that is, to give the system a hint about what will really happen next—but no longer has to oversee things as carefully.

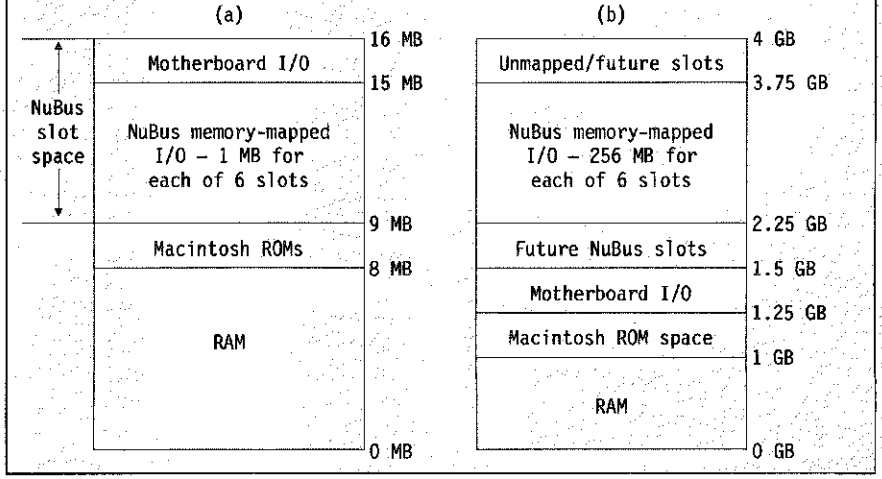
Virtual had to overcome another knotty technical problem. It couldn't swap out its own code (of course), nor could it swap out the disk routines that do the swapping, the interrupt service routines, or the data used by any of this code. Clearly, an intimate knowledge of the Macintosh ROMs and OS was required.

BEYOND THE 8MB BARRIER

Even though 24-bit addresses give the Macintosh an address reach of 16MB, not all of this space was originally intended to be RAM. The early Mac designers, not anticipating users' future memory needs, expected that only the lower 8MB of the address space would ever be used for RAM. Figure 5a shows the layout of the 24-bit address space. Note that each slot on the Mac II's NuBus was allocated a full megabyte for use in memory-mapped peripherals. (The motherboard, which was technically considered to take up one slot, mapped its peripheral chips into the very highest addresses.)

The first version of Virtual made no changes to the operating system traps and calls; it could fill in the area below 8MB only with virtual memory. Using the next megabyte of address space would hide the Macintosh ROMs (whose addresses are hard-coded to start at 8MB) from the rest of the system. This was useful if you had not fully populated the motherboard on your Mac II, but if you already had 8MB of physical RAM, no contiguous address space was left for virtual

FIGURE 5: 24-bit and 32-bit Macintosh address spaces



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memory. However, the current version of Virtual *can* use some of the space above the top of ROM for virtual memory, provided the NuBus slot to which it's mapped isn't occupied.

To provide this feature, Virtual had to begin trapping requests for memory both from applications and from the operating system. Many programs, including MultiFinder, expect to allocate memory in contiguous chunks, and the space reserved for the ROM gets in the way. Virtual gets around this by trapping memory requests that would overlap the ROM—and turning the ROM into a nonrelocatable heap block.

If you're willing to put more than 8MB of physical RAM into your machine, Virtual can also do another neat trick. Some manufacturers have created NuBus memory cards that add memory in the NuBus slot space; alas, because the Macintosh Memory Manager wasn't designed to use this space, the RAM can be used only as a RAM disk or disk cache. Virtual, however, can let the system use this physical RAM in the same way it can put virtual memory at those addresses.

Your video card and the motherboard will always take up 2MB of the high memory space, and the ROMs currently consume only 128K of their 1MB, so you're left with 14.75MB of address space for real and virtual memory in 24-bit mode. (You always get this much on an SE 30, because you can't add cards to it.) But in 32-bit mode—now available to device drivers and usable by all applications under System 7—the memory space explodes to 4GB.

Figure 5b shows the frontiers of the Mac's brave new 32-bit world. A whopping 1GB of space is reserved for system RAM; the remaining space contains the ROM and peripheral cards (and, presumably, more physical or virtual memory). Each NuBus slot gets 256MB of the 4GB address space. But will the Macintosh ROMs work in this new configuration? A quick look at the latest ROMs shows that they will. Apple has cleverly set things up in anticipation of this scheme; all the internal jumps go to addresses such as 4080XXXXh. The "40" in the high byte, ignored in 24-bit mode, will direct the CPU to the correct address in 32-bit mode.

VIRTUAL VS. MAC VM

Frustrated Apple developers sometimes protest that as soon as a company markets a brilliant product for an Apple computer, Apple steps in and attempts to take over the market. In this case, their complaints may be justified: Mac VM, Apple's virtual memory manager for System 7, does exactly the same thing that Virtual does. The biggest difference is that Apple, which has control of the standard and the source code to the system ROMs, has been able to optimize System 7 and Mac VM to work together. New system routines let applications fix blocks permanently in physical memory; this makes it easier to ensure that a critical piece of code does not get swapped out at a bad time. Mac VM still can't do much to prevent Mac programs from corrupting one another's code or data, however; the current architecture of the Mac ROMs (and of many applications) will probably make memory protection impossible anytime in the near future.

There's enough to learn about Macintosh memory management to fill a chapter or two of a good-sized book. If you'd like to delve deeper, you can investigate some of the references in the bibliography. PJ

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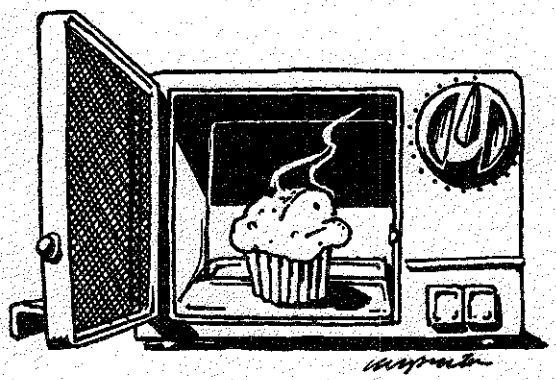
DESQview-aware programs

Enhance BASIC with assembly language modules for DESQview's multitasking



By Murray L. Lesser

Being somewhat multilingual as far as programming languages are concerned, I try to use whichever language is best suited to the application at hand. I can't be bothered to learn the idiosyncrasies of each compiler vendor's "development environment," so I use Quarterdeck's DESQview 386 as a universal programming platform. Using this platform allows me to run lengthy jobs in the background while I write and test programs in the foreground.

My home-grown text-processing utilities are written in compiled Microsoft BASIC enhanced with assembled procedures. Since BC version 4.0, compiled BASIC programs write text-mode display output directly to the display-screen memory when they are linked only to the libraries furnished by Microsoft. Although DESQview 386 can multitask such programs, "plain" DESQview can run programs that write directly to display-screen memory only in a full-screen, foreground window.

I have outsmarted this deficiency by adding a few assembled modules to my BASIC private library to allow me to write "DESQview-aware" programs in BASIC. DESQview-aware programs can run directly under DOS, but they perform even better when running under DESQview. For example, my DESQview-aware BASIC utilities will run in small windows—or even in the background—on my 640K, diskette-only, 80C88-powered laptop, letting me take advantage of the DESQview user-interface capabilities.

In what follows, I present two assembled private-library modules. One is a function that returns a long-integer value corresponding to the DOS clock time. The second module makes command calls to the DESQview Application Program Interface (DVAPI) if the program is running under DESQview: one linkable procedure allows compiled BASIC programs to break out of their time slice while waiting in a polling loop; the other forces BASIC to write to DESQview's "shadow" display memory segment instead of directly to the screen memory. The use of these three procedures is illustrated by a short BASIC "alarm clock" program.

TIME DELAYS

DESQview is a preemptive multitasking environment that runs under DOS. Each active task is given its time slice in turn. Time slices are measured in BIOS clock ticks; typical values for an 80386-powered machine are nine ticks for the foreground task, followed by two ticks for each active background task. DESQview switches to the next task in the sequence when the current time slice is ended, when DESQview notes that the current task is waiting for a keystroke entry, or if the task executes a DVAPI PAUSE command. This last technique is the only way DESQview can "know" that it is just waiting around during a polling loop.

Programs assuming continuous control of all system resources do not operate correctly under DESQview. The most common unusable programs are those that measure time delays by counting BIOS clock tick interrupts. Acceptable time delays are measured by direct comparison with the DOS clock time (which is precise to 10 milliseconds) or with the underlying BIOS timer count (accurate to about 55 milliseconds).

In general, using a language library's "time delay" function in a program running under DESQview is a poor use of hardware resources: a well-designed library delay function is a polling loop that will most likely spend its entire time slice waiting for nothing to happen. SLEEP, the delay function introduced in BC 4.5, also contains a built-in booby trap: the delay is ended by any keystroke, so switching a task from foreground execution to background during a SLEEP delay ends the delay.

The traditional BASIC function for building time-delay loops (or for measuring time intervals) is TIMER. TIMER

Murray L. Lesser is a retired IBM engineer. He has written three books about enhancing various Microsoft BASIC compilers with assembled modules. The most recent, Advanced QuickBASIC 4.0, *was published by Bantam.*

ILLUSTRATION BY JIM CARPENTER

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LISTING 1

```
        TITLE   Time in Hundredth-seconds
        .MODEL  MEDIUM
;                               HUNDSECS.ASM
; HUNDSECS [DECLARE FUNCTION HUNDSECS& ()]: an assembled function for com-
; piled BASIC programs that returns the system time of day in hundredths of
; seconds as a long integer. It serves the same purpose as the intrinsic
; BASIC function "TIMER" but doesn't require using floating-point arithmetic.
; Written by M. L. Lesser, December 25, 1990.
; Assembled with Microsoft MASM, version 5.1

.CODE
        PUBLIC  HUNDSECS
HUNDSECS PROC
        PUSH    BP
        MOV     AH,2CH          ;DOS "Get time" function
        INT     21H
        MOV     AL,60
        MUL     CH              ;Hours -> minutes in AX
        XOR     CH,CH
        ADD     AX,CX           ; + Minutes
        XCHG    DX,BX           ;Put Seconds and Hundreds in BX
        MOV     CX,6000         ;Hours + minutes -> seconds * 100
        MUL     CX              ;  in DX:AX
        XCHG    AX,CX           ;Now in DX:CX
        MOV     AL,100
        MUL     BH              ;Seconds * 100 in AX
        XOR     BH,BH
        ADD     AX,BX           ; + Hunds
        ADD     AX,CX           ;Low order of final value
        ADC     DX,0            ;High order
        POP     BP
        RET
HUNDSECS ENDP
        END
```

LISTING 2

```
        TITLE   DESQview Aware Procedures
        .MODEL  MEDIUM
;                               DVAWARE.ASM
; Two assembled subroutines to allow compiled BASIC programs to be "DESQ-
; view aware." These routines have no effect when the program is running
; directly under DOS.  DVBREAK [DECLARE SUB DVBREAK ()] stops the time
; slice if the program is running under DESQview. DVSHADOW [DECLARE SUB
; DVSHADOW ()] allows programs compiled with BC 4.0, or later, to run in
; the background or in small windows under "plain" DESQview. The CALL
; DVSHADOW statement must be executed before any PRINT statement in the program.
;   WARNING:  BASIC programs using either of these procedures must be com-
; piled with switch "/O" for standalone use.
; Written by M. L. Lesser, August 7, 1990
; Assembled with Microsoft MASM, version 5.1

IF1
        INCLUDE DVAPI.INC               ;From DVAPI Reference Library
ENDIF

.DATA
        EXTRN   B$VideoBase: WORD       ;Base of (text) screen memory

.CODE

DVPRES  PROC NEAR               ;Local (non-public) subroutine to check
        @CALL   DVPRESENT       ;  for DESQview presence.
        OR      AX,AX           ;Will be zero if not running under DV
        RET
DVPRES  ENDP

        PUBLIC  DVBREAK
DVBREAK PROC
        PUSH    BP
        CALL    DVPRES
        JZ      DONE                    ;If not under DV, quit
        @CALL   PAUSE                   ;Else drop time slice
        JMP  SHORT  DONE
DVBREAK ENDP

        PUBLIC  DVSHADOW
DVSHADOW PROC
        PUSH    BP
        CALL    DVPRES
        JZ      DONE                    ;If not under DV, quit
        @CALL   SHADOW                  ;Else tell DV to shadow output
        MOV     B$VideoBase,ES
DONE:   POP     BP
        RET
DVSHADOW ENDP
        END
```

LISTING 3

```
'                               ALARM.BAS
'    ALARM allows a pseudo alarm clock to be set and rings system bell when
' time is reached.  Alarm is designed to operate in the background or in a
' small window under DESQview. WARNING: ALARM must be compiled for
' standalone ("/O" switch) for DVSHADOW to operate.
' Written by M. L. Lesser, 12/25/90
' Compiled with Microsoft BC 7.1, switch "/O". Linked to HUNDSECS, DVAWARE,
' and the BASIC 7 stub file NOFLTIN with switches "/E/NOE"


   DEFINT H,M                   'Integer variables: HERE, HOURS, MINUTES
   DEFLNG N,A                   'Long variables:  NOW, ALARM
   DECLARE FUNCTION HUNDSECS& ()
   DECLARE SUB DVBREAK ()
   DECLARE SUB DVSHADOW ()

   DVSHADOW                     'No effect if not running under DV
   CLS
RESTART:                'Restart point for invalid input alarm time
   LET HERE = CSRLIN
   GOSUB SHOWTIME               'Use GOSUB to save space and time
   PRINT
   INPUT "Enter alarm-set time (hh,mm):  ", HOURS, MINUTES
   IF HOURS < 0 OR HOURS > 23 OR MINUTES < 0 OR MINUTES > 59 THEN
      PRINT  "Invalid set-alarm time.  Enter again."
      GOTO RESTART
   END IF
   LET ALARM = 360000& * HOURS + 6000& * MINUTES
' ALARM is the alarm setting in hundredths of seconds. If alarm is set
'  before current time, assume alarm is intended to be pm; add
'  4,320,000 hundredth-seconds (12 hours) to setting time.  If the
'  result is now greater than 8,640,000 hundredth-seconds, or is still
'  less than current time, assume an attempt was made to set the alarm
'  for tomorrow and terminate the program.
   IF ALARM <= HUNDSECS THEN
      LET ALARM = ALARM + 4320000&
      IF ALARM >= 8640000& OR ALARM <= HUNDSECS THEN
         PRINT "  Cannot set alarm for tomorrow"
         PRINT "Press any key to terminate program"
         WHILE LEN(INKEY$) = 0: WEND
         END
      ELSE
         LET HOURS = HOURS + 12
      END IF
   END IF
   PRINT "  Alarm is set for" STR$(HOURS) ":";
   IF LEN(STR$(MINUTES)) = 2 THEN PRINT "0";
   PRINT LTRIM$(STR$(MINUTES))
   LET HERE = CSRLIN
   WHILE HUNDSECS < ALARM               'Wait for the alarm to go off
      GOSUB SHOWTIME                    '  showing current time
      IF INKEY$ = CHR$(3) THEN END      '   but allow Ctrl-C escape
      DVBREAK                           'Exit time slice if under DV
   WEND
   PRINT: PRINT "Press any key to turn off bell and terminate program."
   IF CSRLIN = 24 THEN LET HERE = 22
AROUND:                         'Start of GOTO loop ringing alarm bell
   LET NOW = HUNDSECS + 100&            'Actually, one second from now!
   BEEP                                 'Ring bell at
   WHILE HUNDSECS < NOW                 '  one-second intervals
      DVBREAK
      GOSUB SHOWTIME                    '  showing time of day
   WEND
   IF LEN(INKEY$) = 0 THEN GOTO AROUND  '  until key is pressed
   PRINT
END

SHOWTIME:       'Local subroutine displaying time of day in place:
   IF HERE > 23 THEN
      PRINT: PRINT
      LET HERE = HERE - 2
   END IF
   LOCATE HERE, 3
   PRINT "It is now:  " TIME$;
RETURN
```


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suffers from the typical ills of computing in floating point: false precision indications, poor performance, and the need to include lengthy emulator code in the executable file. The assembled function HUNDSECS.ASM (Listing 1) returns the DOS clock time, in hundredths of a second since midnight, as a long integer. Text-only programs properly written to use HUNDSECS instead of TIMER can be compiled and linked to omit the floating-point emulator, thereby saving up to 13K of code space.

THE SHADOW KNOWS

The module DVAWARE.ASM (Listing 2) contains three procedures, only two of which have public entry points. (Omitting the language name from the MODEL directive prevents MASM 5.1 from forcing all PROC names to be PUBLIC.) DVPRES, a local procedure, is called by each of the two public procedures—DVBREAK and DVSHADOW—to determine whether or not the program is running under DESQview. If it isn't, neither public procedure has any effect.

Listing 2 contains macros defined in the DESQview DVAPI.INC header file. DVAPI.INC is distributed on diskette with the DESQview API Reference and with any DESQview API (DVAPI) language library. The assembly language expansions of the three @CALL macros I use here are also shown in Appendix J of the DESQview version 2 manual.

The DVBREAK subroutine is used to break out of an active time slice, and it should be included in every polling loop unless you expect the polling period to be less than the minimum time slice.

The DVSHADOW subroutine allows compiled BASIC programs to run in small windows, or in the background, when the programs are running under non-386 DESQview. DVSHADOW then loads the segment address of DESQview's "shadow" display memory into the BASIC global variable **B$VideoBase.**

B$VideoBase exists as a global variable only in programs compiled with the "/O" switch for stand-alone execution. Attempting to link this module into a BASIC program that has been compiled to use BASIC's Run-Time Module produces an "unresolved external" error message. I assume that the module would cause some sort of runtime failure if it were linked into a "Quick" library and used with QBX (or QB), although I have never tried it. Early experience with QuickBASIC demonstrated that many programs would run correctly when compiled with the command-line compiler but not under the "development environment." For other programs, the reverse was true.

Programs that call DVSHADOW (before executing any PRINT statement) should be installed under DESQview with "no" in answer to the "writes directly to screen" and "virtualize text" questions.

Even if you have the DESQview API BASIC Library, you should use the assembled procedures shown here for writing DESQview-aware programs, rather than trying to use the calls in that library. The BASIC Library API calls are useful only for DESQview-specific BASIC programs. Even so, the library does not support the API SHADOW call. You have to add an assembled DVSHADOW procedure if you want your BASIC DESQview-specific programs to run in the background under plain DESQview without using QB45LOAD.COM, which is the library-furnished loader program. (Note that QB45LOAD.COM works only with BASIC programs compiled with the "/O" switch.)

SOUND THE ALARM

Although ALARM.BAS (Listing 3) is a fairly simple program, it serves to illustrate a few of the niceties of running a BASIC program under DESQview using minimal memory. ALARM was written to take into account idiosyncrasies of both the compiler and the DESQview environment. If compiled with BC 7.1 and linked as noted in the listing, ALARM.EXE will run in a DESQview window set for 21K "Memory size" and zero "System Memory" and "Script Buffer" sizes. If compiled with BC 4.5, the program requires 34K of memory.

ALARM requests an alarm-set time from the user. If a valid time is set, ALARM goes into a timing loop (interrupted on each pass by DVBREAK) until the set time is reached. After that point, ALARM goes into a second timing loop, ringing the PC's bell each second until ALARM's window is switched into the foreground and a key is pressed.

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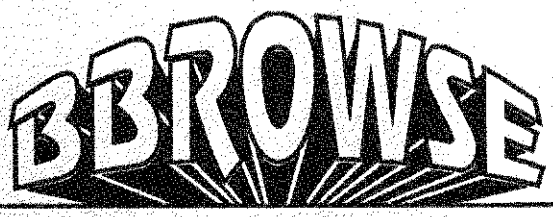
not as smart as they should be. Even though a program appears to have eliminated all statements that use floating-point arithmetic, BC still asks the linker for the emulator if it finds any statement containing an INPUT, READ, or VAL function; the compiler doesn't notice that the same statement also contains the typed variable to which the requested value is to be assigned. The stub file NOFLTIN.OBJ was introduced with BC 7.0. If NOFLTIN is linked with a program containing INPUT or READ statements, it replaces the full emulator with a dummy emulator module, saving about 13K of code space. A bug in the BC 7.0 VAL compilation was worsened in BC 7.1: if the source code contains a VAL statement, NOFLTIN does not prevent the full emulator from being linked into the executable file.

The workaround in ALARM is to avoid using VAL. Instead of parsing a single string input *(hh:mm)* variable to obtain the alarm-set time, the program requests a pair of integer variables *(hh,mm)* that are separated by a keyed-in comma. The neophyte user will receive several unfriendly "Redo from start" error messages until the lesson is learned.

When ALARM is added to DESQview's repertoire, the options are set to block DESQview's "Close window" command and to disallow ALARM's being swapped out of active memory. These options prevent users from inadvertently turning off the alarm before its time, and they assure that ALARM will keep running in the background as long as its window is open. Because there has to be some way to close ALARM's window, the "Close on exit" option is also set.

Using the "Close on exit" option allows ALARM.EXE to be loaded by DESQview's own loader, rather than by a copy of COMMAND.COM, thereby reducing the minimum program memory size. Directly loaded programs should not contain any automatic error terminations, because any message explaining the termination will be lost when the window vanishes. This is illustrated in ALARM by the forced termination of any attempt to set the alarm for the next day. Although the termination cannot be prevented, it is not effective until the "error" is acknowledged with a keystroke. ALARM can be terminated before its time by switching its window to the foreground and pressing Control-C.

ALARM was written originally to be a test-bed for studying DESQview-aware programming in BASIC, and it has been enhanced several times to add function while reducing its minimum program memory size. In spite of its being only an exercise, I find it a useful utility to prevent my becoming so immersed in the computational muse that I forget an appointment. My reminder to set the alarm is a DESQview "startup" script (see the DESQview version 2 manual, Chapter 5), which opens the ALARM window for me at the beginning of every DESQview session. PJ



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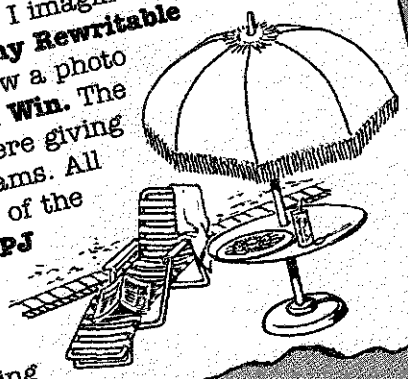
CONTEST

How I got rich and famous reading Programmer's Journal

by Programmer Bob

t was a bright and sunny day. There I was, relaxing with my 50-MHz 486 PC laptop beside my Olympic-sized swimming pool, reading my favorite magazine, **Programmer's Journal.** By the way, I'm Bob, the tanned and sophisticated computer programmer. As I devoured the code-intensive pages, the enlightening articles, and a platter of chilled crudités, I imagined how perfect life would be if only I had a **650-MB Sony Rewritable Optical Disk Drive with media.** Suddenly, I saw a photo of the drive along with the words **Contest** and **Win.** The marvelous folks at **Programmer's Journal** were giving me a chance to own the hardware of my dreams. All I had to do was send them a story about one of the many occasions when some tip or article in **PJ** had saved me time and money. "I'm really too busy for this," I thought as I sipped my iced tea. "But everyone loves hearing about the time when I was designing the [illegible] killer applicat[illegible]



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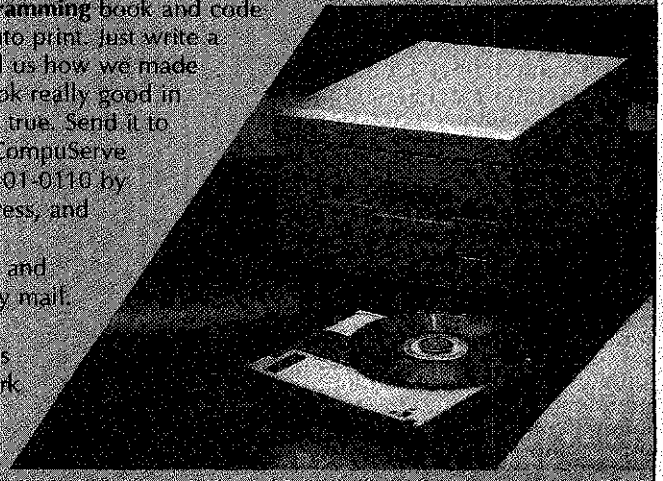
WIN



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Windows property lists

Use Windows 3 features to simplify linked-list management

By William S. Hall

Based on what you read about Windows 3.0 enhanced mode, you might expect that memory is no longer an issue in Windows programming. Not so! DOS may have its 640K limit, but Windows also has some significant—albeit different—limits when it comes to managing memory. This article addresses some of these memory issues and describes some solutions that are based on a Windows network-management application we were developing.

One of the first tasks we faced in developing a Windows program to manage networks was to draw a logical map of each network segment discovered by the hardware device. Each map was to show the various nodes on the segment (PC, bridge, router, etc.) and was to be drawn in a separate multiple document interface (MDI) child window of the main program.

With an unpredictable number of nodes, the map could be described easily using a doubly linked list in which each list element contained descriptive information about its corresponding network node. At the beginning of the project, we simply created a list for each segment in the program's local heap using the rich set of heap-management functions available in Windows. As the program grew and various program features became operational, Windows felt the pinch in its one 64K data segment. It was simple to work around this limit by moving the list to the global heap, because a number of the local and global heap functions mimic each other. For each network segment, memory was allocated from the global heap.

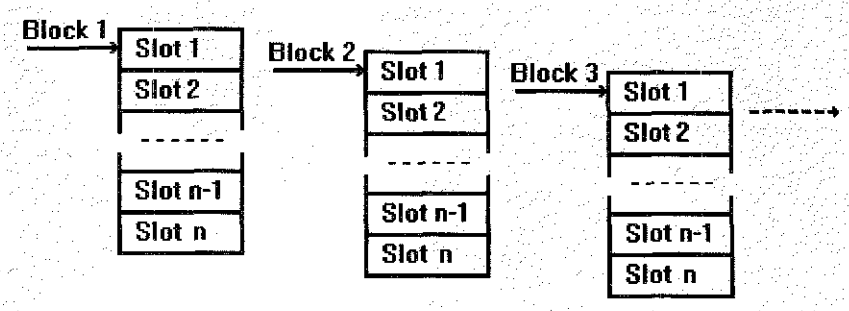
Then, one day, we connected the network hardware to a large government network. The Windows program ground to halt: it had run out of selectors. At the time, we were naively using one selector per node—but the target network had segments with thousands of nodes. With a maximum of 8,192 selectors available in Windows, it was time to find an alternative approach to managing the linked list.

The solution was to manage the memory in uniformly sized blocks divided up into slots of equal size (Figure 1). Each slot would contain the information that previously had been contained in one element of the list. By using just one selector for each block and many slots per block, the demand for selectors could be greatly reduced. Of course, such a scheme would require a certain amount of overhead for storing the current block and slot numbers, as well as pointers to each block. And each set of data needed to be associated with the window supporting the network map.

PROPERTY LISTS RIDE AGAIN

Thus, the block memory-management system suggested the use of a *property list*. A property list allows you to associate a number of arbitrary 16-bit quantities with a given window. You need two things: a property name (a character

FIGURE 1: Diagram of the memory-management system



William S. Hall is a senior engineer at Novell, in San Jose, California. He specializes in Windows software.

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string) and a handle to a window (to place the data item on the window's property list). You can retrieve, remove, or enumerate this data at any time. By using the property list, you can simplify information storage and avoid building complex data structures.

In what follows, I will describe the various Windows property list functions and illustrate them with a Windows program that contains the elements of the memory-management scheme described above. The program also shows how to simplify the display of information by using a predefined control class (in this case a listbox) in your main window.

TOGETHER AT LAST

There are two ways to store data that is unique to a given window. If you know the size of the data, you can use the **cbWinExtra** field in the WNDCLASS data structure. When the Windows class is registered, just declare the amount of extra data space you want. If you need to tie an unknown number of 16-bit entities to a given window, however, a property list becomes convenient.

Property lists are storage areas that contain handles for data associated with a window. Property lists are especially useful for working with predefined Windows classes such as EDIT, LISTBOX, and DIALOG. Because you have no control over the allocation of extra bytes, they cannot be assigned in the class structure, but you can store information conveniently in a property list as long as the window exists. Of course, each property requires a unique string, but these are easily manufactured by concatenating a single string with a unique integer value that has been converted to a string.

PROPERTY LIST FUNCTIONS

Four functions are available for manipulating the property list. **SetProp** adds entries to the list. Each entry contains a unique text string and a data handle; the string identifies the handle, and the handle describes the data. Instead of strings, you can use atoms (integers that uniquely identify strings) to describe properties. The atom must first be created by the **AddAtom** (or **GlobalAddAtom**) function. When you call **SetProp,** you then pass it the atom rather than the string.

Once an item is in the property list, any application can access the data using **GetProp** if the window handle and the string (or atom) are known. Information can be shared, but the usual caveats about using another program's handles apply: only global memory objects—such as GDI objects—can be used by other applications. If a property list contains local or global memory handles or resource handles, they belong exclusively to the program that created them.

EnumProps enumerates the contents of a property list. This function requires that the application declare a callback function to receive the data handle and string of each entry in the list. The callback function can perform any task.

Properties are removed from the list using **RemoveProp.** When a window is destroyed or when the program terminates, it is especially important to remove all the properties that were added by the application.

Although the data handles in a property list always belong to the application that created them, the property list itself belongs to Windows. The property list is allocated in the local heap of the USER library (USER.EXE); this space is also used for other data related to each window in the system. Because the USER data segment—and hence its local heap—cannot exceed 64K, excessive use of property lists can deplete Windows' resources. For a discussion of resources (extracted from the Windows SDK), see the "Windows Resource Limits" box on p. 54. You can view the current state of resources in the Program Manager's "About" box (Figure 2).

The Presentation Manager (PM) SDK contains a programmer's note that can give you insight into how property lists work. PM has no property lists, but you can achieve the equivalent function by creating a linked list in memory and placing a pointer to it in the Windows extra-bytes area. Of course, you must construct the corresponding property-management functions as well.

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FIGURE 2: The Program Manager's "About" box

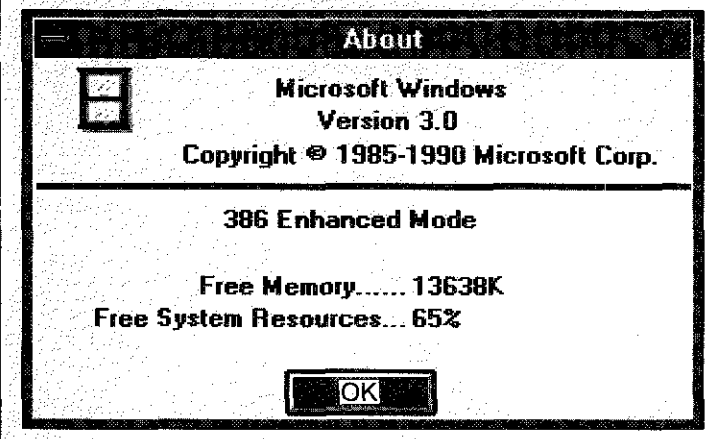
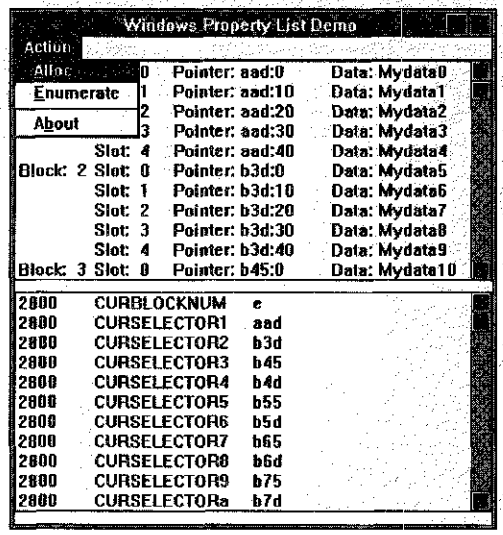


FIGURE 3: Property list enumeration


Windows Property List Demo
Action
Alloc
Enumerate
About
0 Pointer: aad:0 Data: Mydata0
1 Pointer: aad:10 Data: Mydata1
2 Pointer: aad:20 Data: Mydata2
3 Pointer: aad:30 Data: Mydata3
Slot: 4 Pointer: aad:40 Data: Mydata4
Block: 2 Slot: 0 Pointer: b3d:0 Data: Mydata5
Slot: 1 Pointer: b3d:10 Data: Mydata6
Slot: 2 Pointer: b3d:20 Data: Mydata7
Slot: 3 Pointer: b3d:30 Data: Mydata8
Slot: 4 Pointer: b3d:40 Data: Mydata9
Block: 3 Slot: 0 Pointer: b45:0 Data: Mydata10
2800 CURBLOCKNUM e
2800 CURSELECTOR1 aad
2800 CURSELECTOR2 b3d
2800 CURSELECTOR3 b45
2800 CURSELECTOR4 b4d
2800 CURSELECTOR5 b55
2800 CURSELECTOR6 b5d
2800 CURSELECTOR7 b65
2800 CURSELECTOR8 b6d
2800 CURSELECTOR9 b75
2800 CURSELECTORa b7d

HEAPING BIG MEMORY

WALLOC.EXE uses the property list functions to implement the memory-management scheme described above. The goal is to provide a long pointer to a fixed-size chunk of memory in the global heap on each allocation request. The memory can be used in any way. In its original implementation in the network-management program, the block is an element in a linked list containing data and pointers to the next and previous members. Generally, the list only grows, and it exists for the life of the window. Nodes are occasionally moved but rarely removed. Hence, there is no need for memory deallocation (or garbage collection and compacting) except when the window that manages the list is itself destroyed.

The scheme uses property list strings to represent the current block number, the current slot within the block, and the block's selector (or, if in real mode, segment) value. There is also a constant value (not placed on the property list), which is the number of memory slots in each memory block.

On each allocation request the following sequence occurs. If a new block is to be allocated, a call is made to Windows via **GlobalAlloc.** The allocation size is the requested size multiplied by the number of memory slots in each block. (If this latter value is *n*, then the number of selectors needed per chunk of memory is reduced by this factor.) If the allocation succeeds, the required memory will be used for a long time, so the handle that is returned is wired by using **GlobalWire.**

Then the three properties on the list are updated. The first property is the current block number, which is incremented by 1. The second is the slot number, which is reset to 0 because this is the first slot in a new block. Finally, the selector (or segment) returned by **GlobalWire** is placed on the property list. The string used for this property is a concatenation of a constant string and the block number. The allocation function returns with the long pointer obtained from **GlobalWire**, or with NULL if the allocation fails or the property list is full.

If the slot number has not exceeded the maximum number of slots per block, then the property containing the slot number is incremented by 1. The current selector on the property list is read, and then an offset value is constructed by multiplying the current slot number by the size of the memory allocation. The selector and offset thus calculated are returned to the caller as a long pointer.

As mentioned above, there is no requirement for deallocation of memory during the life of the window. When it is destroyed, however, each added property is removed, and the corresponding memory block is unwired and freed.

After running the program, you'll see three commands listed under the Action menu: **Alloc, Enumerate,** and the ubiquitous **About** box. Each time you activate **Alloc,** another chunk of memory is assigned. Information about its allocation block, slot number, pointer value, and the stored data is added to a listbox that fills the top half of the window's client area.

You can enumerate the current property list at any time using the **Enumerate** command. A listbox on the lower part of the screen displays the properties (see Figure 3).

Accelerator keys make it easy to perform a series of allocations: just hold down the "ALT" and "A" keys. To view the current property list, press the keys "ALT+A+E."

As mentioned, properties end up in USER's heap. You can run the HeapWalker program from the Windows SDK and look for USER's data segment in HeapWalker's window. Double-click on that line to produce a dump of the segment. Now scroll through until you find the expected property strings. Figure 4 shows a partial dump of the heap and the property strings during a run of WALLOC.

THE INITIALIZATION UNIT

A partial listing of the program accompanies this article, and the complete source is available on the *PJ* disk for this issue.

WALLOC is written in the medium model with three code segments. The initialization segment (Listing 2) contains only the routines needed at start-up.

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All is standard except for the creation of two child windows of the listbox class in **WndCreate.** In place of the menu handle, a unique identification number is assigned to each listbox. That way, each child can be treated like a control in a dialog box.

Note that if these child windows cannot be created, then the main program is terminated by posting a WM_SYSCOMMAND message to itself with word parameter SC_CLOSE (instead of by returning FALSE from **InitProgram).** Once the main window has been created, the main message loop begins to execute. If **InitProgram** were to return FALSE at this point, a general protection fault would result.

THE MAIN WINDOW MODULE

The main window procedure is shown in Listing 3. Note the response to WM_SIZE: the two child listboxes are repositioned and sized each time the main window is resized.

This module also contains the menu responses under WM_COMMAND. When the **Alloc** menu command is selected, another chunk of data is allocated; a unique string is copied there and the upper list box is updated.

When **Enumerate** is executed, the properties that have been added to the main window are obtained and placed in the lower listbox. Note the call to reset the redraw flag before the listbox is emptied and filled again; only when

FIGURE 4: Partial dump of the heap and property strings

```
                0007ADA0 06EE  28448 1    User      Data
47B0 0B 43 55 52 42 4C 4F 43 4B 4E 55 4D 00 00 00 00   CURBLOCKNUM
47C0 A9 47 D4 47 00 00 01 00 0A 43 55 52 53 4C 4F 54  ©GÔG      CURSLOT
47D0 4E 55 4D 00 C1 47 EC 47 00 00 01 00 0C 43 55 52  NUM.ÁGìG.    .CUR
47E0 53 45 4C 45 43 54 4F 52 31 00 00 00 D5 47 04 48  SELECTOR1   ÕG.H
47F0 00 00 01 00 0C 43 55 52 53 45 4C 45 43 54 4F 52  .    .CURSELECTOR
4800 32 00 00 00 ED 47 1C 48 0C 2A 01 00 0C 43 55 52  2   íG.H.*    .CUR
4810 53 45 4C 45 43 54 4F 52 33 00 00 00 05 48 34 48  SELECTOR3    H4H
4820 00 00 01 00 0C 43 55 52 53 45 4C 45 43 54 4F 52  .    .CURSELECTOR
4830 34 00 00 00 1D 48 4C 48 00 00 01 00 0C 43 55 52  4    HLH    .CUR
4840 53 45 4C 45 43 54 4F 52 35 00 00 00 35 48 64 48  SELECTOR5    5HdH
4850 00 00 01 00 0C 43 55 52 53 45 4C 45 43 54 4F 52  .    .CURSELECTOR
4860 36 00 00 00 4D 48 7C 48 48 2A 01 00 0C 43 55 52  6   MH|HH*    .CUR
4870 53 45 4C 45 43 54 4F 52 37 00 00 00 65 48 94 48  SELECTOR7    eH.H
4880 00 00 01 00 0C 43 55 52 53 45 4C 45 43 54 4F 52  .    .CURSELECTOR
4890 38 00 00 00 7D 48 AC 48 00 00 01 00 0C 43 55 52  8   }H¬H    .CUR
48A0 53 45 4C 45 43 54 4F 52 39 00 00 00 95 48 C4 48  SELECTOR9    HÄH
48B0 00 00 01 00 0C 43 55 52 53 45 4C 45 43 54 4F 52  .    .CURSELECTOR
48C0 61 00 00 00 AD 48 DC 48 8C 4A 01 00 0C 43 55 52  a   ¬HÜH.J    .CUR
48D0 53 45 4C 45 43 54 4F 52 62 00 00 00 C5 48 F4 48  SELECTORb    ÅHôH
48E0 AC 47 01 00 0C 43 55 52 53 45 4C 45 43 54 4F 52  ¬G    .CURSELECTOR
48F0 63 00 00 00 DD 48 0C 49 50 49 01 00 0C 43 55 52  c   ÝH.IPI    .CUR
4900 53 45 4C 45 43 54 4F 52 64 00 00 00 F5 48 24 49  SELECTORd    õH$I
4910 CC 45 01 00 0C 43 55 52 53 45 4C 45 43 54 4F 52  ÌE    .CURSELECTOR
4920 65 00 00 00 0D 49 4C 49 BC 27 4E 4B 54 D2 00 00  e    .ILI¼'NKTÒ..
```


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the process is complete is the redraw flag set and the listbox repainted. Otherwise, the listbox would be redrawn every time it is emptied and every time another entry is added by the enumeration callback function. The result would be an unpleasant flashing that is painful to the eyes.

This module also contains a useful routine called **dbs.** Windows 3 gave us CodeView but took away a helpful debugging tool: writing formatted information to the debugging monitor using **printf. dbs** provides a handy replacement. It is easy to add to any Windows program, but you should include STDIO.H and STDARG.H in the routine where it is defined. **dbs** is prototyped in WALLOC.H.

Note that you will need Michael Geary's OX.SYS to see the **dbs** output on a secondary monitor. OX.SYS has been around for many years; a copy is included on the *PJ* disk. Install it with the line **device=ox.sys** in CONFIG.SYS.

Listing 4 shows the allocation and deallocation functions, explained above. Also included here are the property enumeration callback and the functions that update the listboxes. The listboxes are treated as controls using **SendDlgItemMessage** with their window numbers as the control IDs.

Why does **AllocMem** remove the current block and slot number properties each time they are changed? In fact, the call to **RemoveProp** is not necessary, but it improves the **EnumProp** display. Whenever the same property is set more than once, the "string" returned by the **EnumProp** callback seems to be an atom that is local to USER. You can see this peculiar behavior by commenting the three **RemoveProp** calls and rebuilding the program. Any attempt to retrieve the string by either **GetAtomName** or **GlobalGetAtomName** results in a general protection fault.

The **make** file (included on disk) is for use with the Microsoft 6.0 C compiler. The target, WALLOC.EXE, is organized so that it can be built independently by NMAKE.EXE (or NMK.EXE) to accommodate the separate phases of linking or resource attachment. Just substitute a double colon for the single colon that separates the final target and its dependencies. This substitution is useful when only resources are being changed, because it avoids an unnecessary link.

Windows Resource Limits

Number of Windows

There is a limit to the number of windows that can be created systemwide. Each window creates a window structure that is allocated out of USER's heap, a data segment that is limited to 64K. This is the limitation. Since there are a number of items that affect the USER's heap, there is no way to determine how much space will be around at any given time. You can use Heap Walker to check the size of USER's data segment.

How Menus Affect Resources

Menus are stored in GDI's heap and they have a large effect on system resources available. If an application loads a menu and doesn't associate it with a window, it must destroy the menu itself. (Menus used with the **TrackPopupMenu** function won't automatically be freed when the application exits.)

Calculating System Resources

The Free System Resources figure in the Program Manager's "About" dialog box is calculated as follows:

$$\%\ \text{free} = \min(\%\ \text{free of USER's heap},\ \%\ \text{free of GDI's heap})$$

$$\%\ \text{free USER or GDI heap} = \frac{(\text{Max heap size} - \text{heap used})}{\text{Max heap size}} * 100$$

The calculation is the same for all modes (although not done for real mode).

The maximum heap size is 64K less the sum of the size of the static variables and the stack.

There is no external API defined to calculate these values.

IN SUMMARY

Property lists in Windows provide an excellent method for storing a collection of 16-bit data elements that are associated in some way with a window or dialog box. Although a bit slower to get and set than **cbWinExtra** data, property lists are especially valuable when you don't know initially how much data will be required. Property lists can also eliminate the need to construct complex data structures—let Windows do the work for you! PJ

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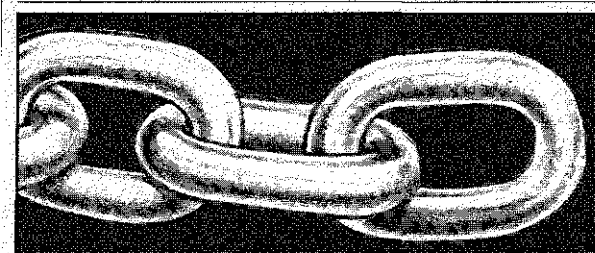
LISTING 1

```
/* Header file for the Windows property list demo
 * Written by Bill Hall */

/* This trick ensures that globals are declared in only one place */
#if !defined(EXTERN)
#define EXTERN extern
#endif

/* Resource string constants */
#define IDS_APPNAME      100
#define IDS_ICON 101
#define IDS_TITLE        102

/* menu items */
#define IDM_ALLOC        100
#define IDM_PROP 101
#define IDM_ABOUT        102

/* dialogs */
#define DT_ABOUT 1

/* Control window id's */
#define IDD_ALLOC        1
#define IDD_ENUM 2

/* Global variables */
EXTERN HWND hWndMain;            /* main window handle */
EXTERN char szAppName[20];       /* name of the application */
EXTERN HWND hWndList;            /* memory allocations display window */
EXTERN HWND hWndEnum;            /* property list display window */
EXTERN HANDLE hInst;             /* instance handle */

/* Declarations which need to be known in several C source files */
LONG FAR PASCAL MainWndProc(HWND,unsigned,WORD,LONG);
BOOL FAR InitProgram(HANDLE, HANDLE, LPSTR, int);
int FAR PASCAL EnumPropCallBack(HWND hWnd, WORD nDummy, PSTR str, HANDLE
                                hData);
BOOL FAR WndCreate(HWND hWnd);
void FAR _cdecl dbs(const char *fmt, ...);

/* memory allocation and property list functions */
void FAR UpdateList(HWND hWnd);
LPSTR FAR AllocMem(HWND hWnd, int size);
void FAR FreeMem(HWND hWnd);

/* Simple data structure to be stored in each chunk of memory allocated */
typedef struct _MYDATA {
    BYTE data[16];
} MYDATA;
```

LISTING 2

```
/* Initialization segment for the Windows property list demo
 * This code is discarded after it is used. */
#define NOCOMM
#define NOKANJI
#define NOATOM
#define NOSOUND
#include <windows.h>
#include <string.h>
#include "walloc.h"

/* local function declarations */
static BOOL NEAR RegisterWindowClass(HANDLE);
static void NEAR GetPrevInstanceData(HANDLE);
static HWND NEAR MakeAndShowMainWnd(HANDLE, int);
```

continued



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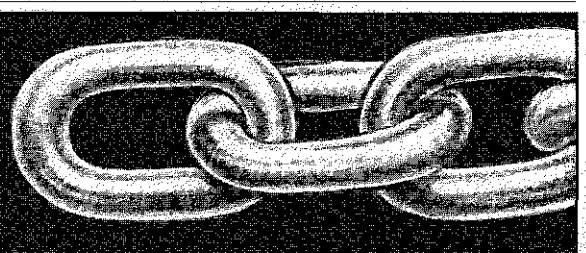

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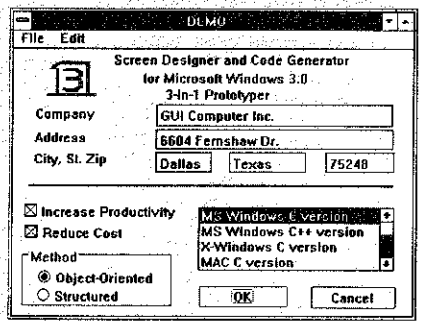

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```
/* This routine is FAR since it is called from another segment */
BOOL FAR InitProgram(HANDLE hInstance, HANDLE hPrevInstance,
                     LPSTR lpszCmdLine, int cmdShow)
{
    hInst = hInstance;
  /* if this is the first instance of the program ... */
    if (!hPrevInstance) { /* register the window */
          if (!RegisterWindowClass(hInstance))
            return FALSE;
    }
  /* A previous instance already exists so get global data from there */
    else
         GetPrevInstanceData(hPrevInstance);

  /* Create and show the window */
    if (!(hWndMain = MakeAndShowMainWnd(hInstance, cmdShow)))
         return FALSE;

  /* Show window if child windows created successfully */
    if (hWndList && hWndEnum) {
        ShowWindow(hWndMain, cmdShow);
        UpdateWindow(hWndMain);
    }
    else /* failed, terminate app */
         PostMessage(hWndMain, WM_SYSCOMMAND, SC_CLOSE, 0L);
    return TRUE;
}

/* Every window must belong to a class. We register ours here */
static BOOL NEAR RegisterWindowClass(HANDLE hInstance)
{
    WNDCLASS WndClass;

  /* Load the name string from resources */
    LoadString(hInstance, IDS_APPNAME,(LPSTR)szAppName,sizeof(szAppName));

    memset(&WndClass, 0, sizeof(WndClass));

  /* fill the structure */
    WndClass.hCursor = LoadCursor(NULL, IDC_ARROW);  /* standard cursor */
    WndClass.hIcon = LoadIcon(hInstance, szAppName);
    WndClass.lpszMenuName = (LPSTR)szAppName;        /* get menu */
    WndClass.lpszClassName = (LPSTR)szAppName;       /* our class name */
    WndClass.hbrBackground = COLOR_WINDOW + 1;       /* system color */
    WndClass.hInstance = hInstance;                  /* instance handle */
    WndClass.style = CS_VREDRAW | CS_HREDRAW; /* standard redraw values */
    WndClass.lpfnWndProc = MainWndProc;       /* pointer to window proc */

    return RegisterClass(&WndClass); /* try to register the class */
}

/* If this not the first instance, we can retrieve static data from a
   previous invocation of the program */
static void NEAR GetPrevInstanceData(HANDLE hPrevInstance)
{
    GetInstanceData(hPrevInstance, szAppName, sizeof(szAppName));
}

/* Create the main window */
static HANDLE NEAR MakeAndShowMainWnd(HANDLE hInstance, int cmdShow)
{
    char szTitle[50];

    LoadString(hInstance, IDS_TITLE, szTitle, sizeof(szTitle));

  /* create the window, letting it fall where Windows wants */
    return CreateWindow(szAppName,
                        szTitle,
                        WS_OVERLAPPEDWINDOW,
                        CW_USEDEFAULT,0,
                        CW_USEDEFAULT,0,
                        NULL,
                        NULL,
                        hInstance,
                        NULL);
}

BOOL FAR WndCreate(HWND hWnd) /* create the child listboxes */
{
    static char *class = "LISTBOX";

    LONG style = WS_CHILD | WS_VISIBLE | WS_BORDER
                 | WS_VSCROLL | LBS_USETABSTOPS;
    hWndList = CreateWindow(class,
```

continued

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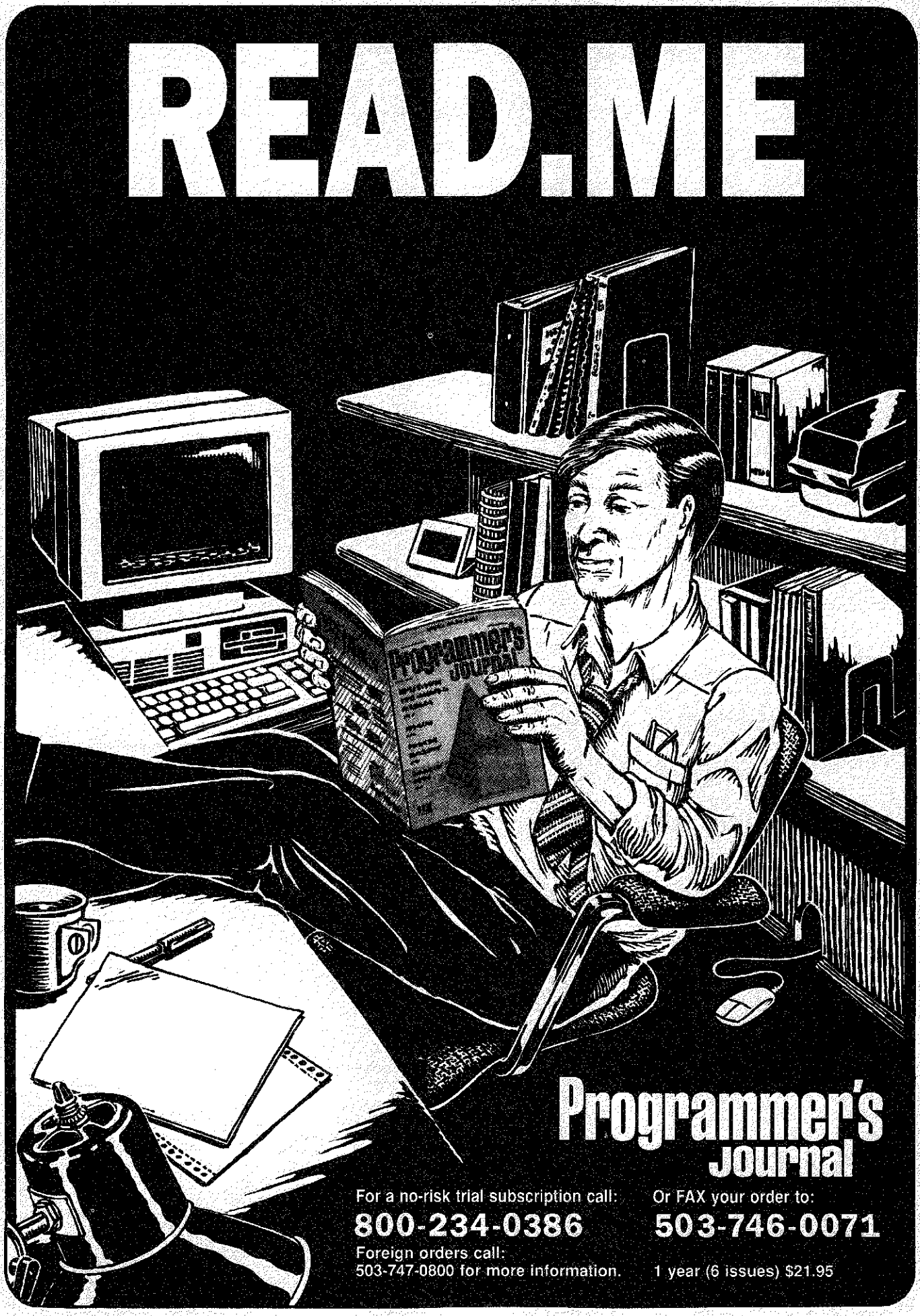

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```
                            NULL,
                            style,
                            0,0,0,0,
                            hWnd,
                            IDD_ALLOC,
                            hInst,
                            NULL);

    hWndEnum = CreateWindow(class,
                            NULL,
                            style | LBS_SORT,
                            0,0,0,0,
                            hWnd,
                            IDD_ENUM,
                            hInst,
                            NULL);

    return (hWndEnum || hWndList);
}
```

LISTING 3

```
/* Resident segment for the Windows Property List Demo */
#define NOCOMM
#define NOKANJI
#define NOSOUND
#include <windows.h>
#include <stdarg.h>
#include <string.h>
#include <stdio.h>

/* all global variables are declared in this module */
#define EXTERN
#include "walloc.h"

/* local function declaration */
BOOL FAR PASCAL AboutDlg(HWND hDlg, unsigned message, WORD wParam,
                         LONG lParam);

/* Entry point for program */
int PASCAL WinMain(HANDLE hInstance, HANDLE hPrevInstance,
                   LPSTR lpszCmdLine, int cmdShow)
{
    MSG msg;

  /* If initialization is not successful then exit */
    if (!InitProgram(hInstance,hPrevInstance, lpszCmdLine, cmdShow))
        return FALSE;

    while (GetMessage((LPMSG)&msg,NULL,0,0)) { /* Retrieve messages */
        TranslateMessage((LPMSG)&msg);
        DispatchMessage((LPMSG)&msg);
    }
    return msg.wParam;          /* exit program */
}

/* All messages are processed here */
long FAR PASCAL MainWndProc(register HWND hWnd, unsigned message,
                            WORD wParam, LONG lParam)
{
    MYDATA FAR *ptr;
    static unsigned count;
    FARPROC fp;

    switch(message) {
        case WM_CREATE:
            WndCreate(hWnd);  /* create the listbox display windows    */
            break;
        case WM_DESTROY:
            FreeMem(hWnd);    /* free allocated memory & property list */
            PostQuitMessage(0);
            break;
        case WM_SIZE:         /* size the list box display windows     */
            if (wParam != SIZEICONIC) {
                MoveWindow(hWndList,0,0,LOWORD
                           (lParam),HIWORD(lParam) / 2,TRUE);
                MoveWindow(hWndEnum, 0, HIWORD(lParam) / 2,
                           LOWORD(lParam), HIWORD(lParam) / 2, TRUE);
            }
            break;
        case WM_COMMAND:
            switch(wParam) {
                case IDM_ABOUT:         /* show about box */
                    fp = MakeProcInstance(AboutDlg, hInst);
                    DialogBox(hInst,MAKEINTRESOURCE(DT_ABOUT),hWnd,fp);
```

continued

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```
                FreeProcInstance(fp);
                break;
            /* allocate a chunk of data; if successful,
               copy in some information and display the result */
                case IDM_ALLOC:
                    ptr = (MYDATA FAR *)AllocMem(hWnd, sizeof(MYDATA));
                    if (ptr) {
                        wsprintf(ptr->data, "%s%u", (LPSTR)"Mydata",
                            count++);
                        UpdateList(hWnd);
                    }
                    break;
            /* enumerate the current property list and display
               it in a listbox.  To keep the display from
               flashing during update, turn off the redraw flag
               before the update and restore it when done. */
                case IDM_PROP:
                    SendDlgItemMessage(hWnd,IDD_ENUM,
                                       WM_SETREDRAW,FALSE,0L);
                    SendDlgItemMessage(hWnd,IDD_ENUM,
                                       LB_RESETCONTENT,0,0L);
                    fp = MakeProcInstance(EnumPropCallBack, hInst);
                    EnumProps(hWnd, fp);
                    FreeProcInstance(fp);
                    SendDlgItemMessage(hWnd,IDD_ENUM,
                                       WM_SETREDRAW,TRUE,0L);
                    InvalidateRect(hWndEnum, NULL, TRUE);
                    UpdateWindow(hWndEnum);
                    break;
            }
            break;
        default:
            return ((long)DefWindowProc(hWnd,message,wParam,lParam));
            break;
    }
    return(0L);
}

/* This function allows you to print debugging information
 * to a secondary monitor attached to a monochrome display
 * card, Hercules board, or equivalent.
 *
 * To use this function you must load the device driver OX.SYS
 * Do NOT run Windows with redirection to AUX.
 *
 * Use dbs just like printf.
 * Example dbs("function foo %d %s\r\n", myint, mystring); */
void FAR _cdecl dbs(const char *fmt, ...)
{
    char buf[255];

    va_list arg_ptr;

    va_start(arg_ptr, fmt);
    vsprintf(buf, fmt, arg_ptr);
    va_end(arg_ptr);

    OutputDebugString(buf);
}

/* show ego box */
BOOL FAR PASCAL AboutDlg(HWND hDlg,unsigned message,WORD wParam,
                         LONG lParam)
{
    switch(message) {
        case WM_INITDIALOG:
            break;
        case WM_COMMAND:
            switch(wParam) {
                case IDOK:
                case IDCANCEL:
                    EndDialog(hDlg, TRUE);
                    break;
                default:
                    return FALSE;
            }
            break;
        default:
            return FALSE;
    }
    return TRUE;
}
```

continued

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LISTING 4

```
/* Memory allocation and property list functions for
 * the Windows property list demo */
#define NOCOMM
#define NOKANJI
#define NOSOUND
#include <windows.h>
#include "walloc.h"

/* local function declaration */
static LPSTR NEAR WirePointer(DWORD size);

/* property list strings */
static char *szCurBlockNum = "CURBLOCKNUM";
static char *szCurSlotNum = "CURSLOTNUM";
static char *szCurSelector = "CURSELECTOR";

/* locally shared variables */
static int slotsize;

/* definitions */
#define SLOTS_PER_BLOCK  5

/* Allocate a memory chunk and store the information
 * on the window property list.  Memory is allocated in
 * a block whose size depends on the number of slots
 * desired and the size of an individual chunk.  It
 * is assumed that a chunk of memory always has the
 * same fixed size. */
LPSTR FAR AllocMem(HWND hWnd, int size)
{
    WORD CurBlockNum;    /* current block and slot numbers */
    WORD CurSlotNum;
    LPSTR memptr;        /* memory pointer */
    WORD sel;            /* selector (or segment) value */
    WORD offset;         /* pointer offset */
    char buf[30];        /* space for property strings */
    WORD handle;

    CurBlockNum = GetProp(hWnd, szCurBlockNum);   /* get current block */
    CurSlotNum = GetProp(hWnd, szCurSlotNum);     /* and slot number */

    /* we are either starting off the allocation or we have to
       create a new block */
    if ((CurBlockNum == 0) ||((CurBlockNum > 0) &&
        (++CurSlotNum == SLOTS_PER_BLOCK))) {
        slotsize = size;
        /* keep the pointer for the life of the program */
        memptr = WirePointer(size * SLOTS_PER_BLOCK);
        if (memptr) {
            sel = HIWORD(memptr);        /* break pointer into components */
            offset = LOWORD(memptr);
            CurBlockNum += 1;            /* increment block number */
            CurSlotNum = 0;              /* new slot number is 0 */
        /* remove old props before changing values
         * this step is not necessary but improves
         * the display during EnumProps */
            RemoveProp(hWnd, szCurBlockNum);
            RemoveProp(hWnd, szCurSlotNum);
            SetProp(hWnd, szCurBlockNum, CurBlockNum); /* set the new ones */
            SetProp(hWnd, szCurSlotNum, CurSlotNum);
            /* make a unique string identifying the block */
            wsprintf(buf, "%s%x", (LPSTR)szCurSelector, CurBlockNum);
            if (!SetProp(hWnd, buf, sel)) {      /* save to property list */
                handle = LOWORD(GlobalHandle(sel));/* failed, free allocation */
                GlobalUnWire(handle);
                GlobalFree(handle);
                memptr = NULL;
            }
        }
    }
    /* we are simply adding a new slot to the current block */
    else {
        /* build string identifying the current block */
        wsprintf(buf, "%s%x", (LPSTR)szCurSelector, CurBlockNum);
        sel = GetProp(hWnd, buf);        /* get the selector */
        offset = CurSlotNum * size;      /* create the offset */
        memptr = (LPSTR)MAKELONG(offset, sel);  /* make the pointer */

    /* this next step is not really necessary but
     * it improves the display during EnumProps */
        RemoveProp(hWnd, szCurSlotNum); /* update current information */
        SetProp(hWnd, szCurSlotNum, CurSlotNum);
    }
    return memptr;
}

/* free all allocated memory and remove the property list items */
void FAR FreeMem(HWND hWnd)
{
    register WORD i;
    WORD CurBlockNum = GetProp(hWnd, szCurBlockNum);
    WORD cursel;
    char buf[30];
    WORD handle;
    BOOL result;

    for (i = 1; i <= CurBlockNum; i++) {
        /* create the property list identifier */
        wsprintf(buf, "%s%x", (LPSTR)szCurSelector, i);
        cursel = GetProp(hWnd, buf);     /* get the selector */
        handle = LOWORD(GlobalHandle(cursel));  /* convert to handle */
        result = GlobalUnWire(handle);  /* release the allocation */
        result = GlobalFree(handle);
        RemoveProp(hWnd, buf);          /* remove the property */
    }
    RemoveProp(hWnd, szCurBlockNum);     /* remove remaining properties */
    RemoveProp(hWnd, szCurSlotNum);
}

/* add the most recent allocation in the allocation list box */
void FAR UpdateList(HWND hWnd)
{
    WORD CurBlockNum, CurSlotNum;
    char buf[80];
    int pos;
    WORD sel, offset;
    MYDATA FAR *ptr;

    /* get the current block and slot numbers */
    CurBlockNum = GetProp(hWnd, szCurBlockNum);
    CurSlotNum = GetProp(hWnd, szCurSlotNum);

    /* build a pointer to the data in a slot */
    wsprintf(buf, "%s%x", (LPSTR)szCurSelector, CurBlockNum);
    sel = GetProp(hWnd, buf);
    offset = CurSlotNum * slotsize;
    ptr = (MYDATA FAR *)MAKELONG(offset, sel);

    /* build a string to be inserted into the listbox */
    if (CurSlotNum == 0)
        wsprintf(buf, "Block: %2u\tSlot: %2u\tPointer: %x:%x\tData: %s",
                 CurBlockNum, CurSlotNum, sel, offset, (LPSTR)ptr->data);
    else
        wsprintf(buf, "\tSlot: %2u\tPointer: %x:%x\tData: %s",
                 CurSlotNum, sel, offset, (LPSTR)ptr->data);

    /* insert into listbox */
    pos = (int)SendDlgItemMessage(hWnd, IDD_ALLOC,
                                  LB_ADDSTRING, 0, (LONG)(LPSTR)buf);
    /* highlight the new entry */
    if (pos != LB_ERR)
        SendDlgItemMessage(hWnd, IDD_ALLOC, LB_SETCURSEL, pos, 0);
    else
        MessageBeep(0);
}

/* allocate global data and wire the pointer */
static LPSTR NEAR WirePointer(DWORD size)
{
    HANDLE hmem = GlobalAlloc(GMEM_FIXED | GMEM_ZEROINIT, size);
    if (hmem)
        return GlobalWire(hmem);
    else
        return (LPSTR)NULL;
}

/* enumerate the property list and display in listbox */
int FAR PASCAL EnumPropCallBack(HWND hWnd, WORD nDummy,
                                PSTR str, HANDLE hData)
{
    char buf[80];

    if (nDummy != 0)
        wsprintf(buf, "%x\t%s\t%x", hWnd, (LPSTR)str, hData);
    else
        wsprintf(buf, "%x\t%x\t%x", hWnd, str, hData);
    SendDlgItemMessage(hWnd,IDD_ENUM,LB_ADDSTRING,0,(LONG)(LPSTR)buf);
    return TRUE;
}
```


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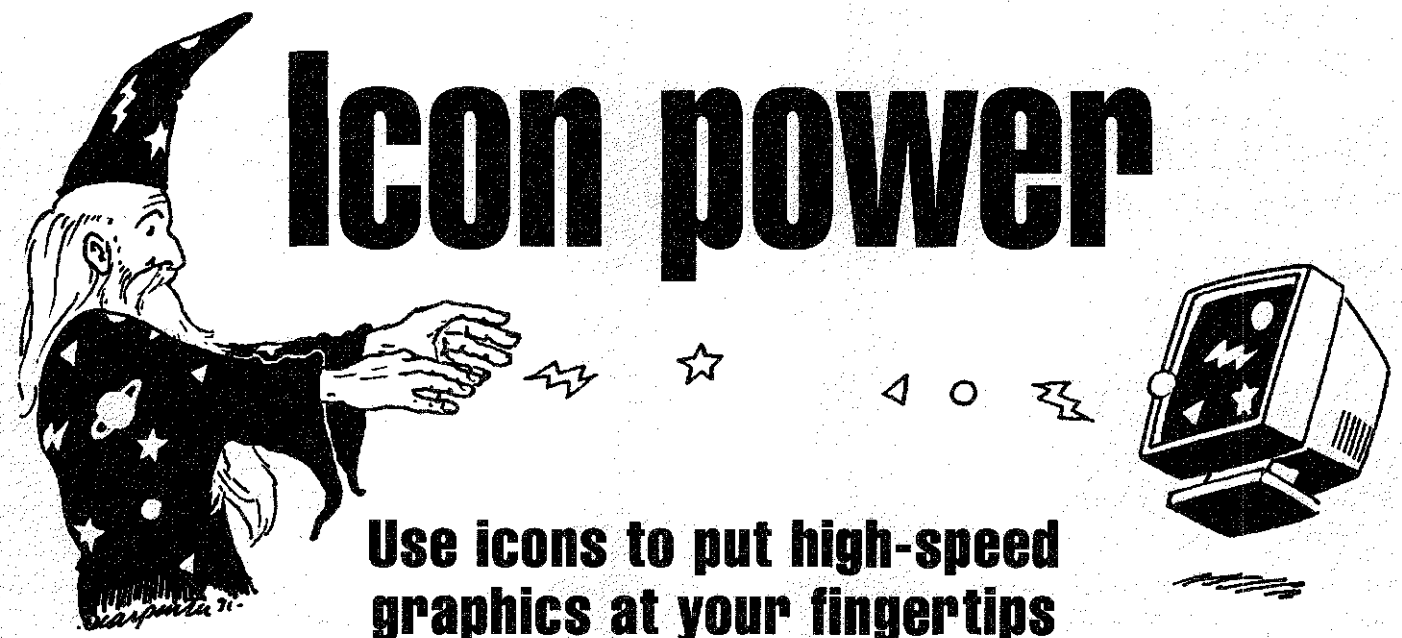

Icon power

Use icons to put high-speed graphics at your fingertips

By Peder Jungck

In my last article ("Pixel panning," *PJ* 9.3), I explained how to use pixel panning and how to remap the video adapter memory to create useful effects. This article examines another tool—icons—and discusses how icons can be useful in the development of professional graphics software.

When icons are mentioned, most people think of Microsoft Windows or the Macintosh: graphical user interfaces have defined icons as things that represent specific objects. But an icon can also be defined as a collection of pixels that forms an image. As such, they are excellent building blocks for full-screen graphical applications. Rather than drawing many different full-screen images in real time, you can generate several small images—namely, icons—that can be pieced together to create a full-screen display. The use of icons can speed the development and runtime of graphics generation, reduce memory use, and simplify complex images. If you're not familiar with the benefits of icon use, take a look at some video games and note the difference between background and foreground objects. Generally, the foreground consists of moving icons, and the background is a repeated pattern of fixed icons.

Like many programmers, I am not a graphic artist, and the use of icons as building blocks has improved the visual quality of my applications. Using icons, you can focus on drawing a single image. If it doesn't look right, you can modify it until you like what you see. A composite of these icons presents an impressive full-screen image that is easy to generate.

Drawing icons can be especially speedy if you predetermine fixed data sizes. When fixed data sizes are used, the display code doesn't have to adapt dynamically. If one icon can be repeated to form a pattern, you can save RAM and, with a few tricks, improve display speed.

There are times, however, when drawing a screenful of data from system RAM to the video board using icons is slower than using a single, large image. For example, the entry and exit code used by the icon display routines will slow image generation if you are copying many different icons to fill the display. Because a single image display routine does not have the entry and exit code overhead for the same amount of data, it can be faster. So don't throw away those other icon libraries—a full-screen image paint routine can sometimes be the best option.

USE THE WRITE MODE

Depending on their design and implementation, your icons can often be streamlined. If you have small objects or much repetition of patterns, you can place one of each icon into off-screen video memory and then use the EGA/VGA write mode 1 to do a very fast move. When you read from a memory location in write mode 1, all four planes of data are moved into their corresponding latches. Each plane is 64K, and all the planes have the same segment address. A subsequent write takes the data from the latches and copies it to a new memory location. Because the data being moved stays in the latches on the video board, the main bottleneck to placing data in video RAM—the bus—is avoided. Using a single **movsb** statement, four bytes of data can be copied into the latches and then to the new memory location (see **Copy_Icon,** Listing 1).

Another benefit of using this feature of write mode 1 is that the video board does not care what the settings are in the Set/Reset, Data Rotator, ALU, and Bit Mask registers; thus, they need not be set before the data is copied. The Map Mask register is still active, so you can select specific planes. These registers do not affect the data, because the data must flow from the system RAM

Peder Jungck, a software engineer, is the author of the ProGraphx Toolbox EGA/VGA graphics library. He can be reached at 1019 West Lovers Lane, Arlington, TX 76013.

ILLUSTRATION BY JIM CARPENTER

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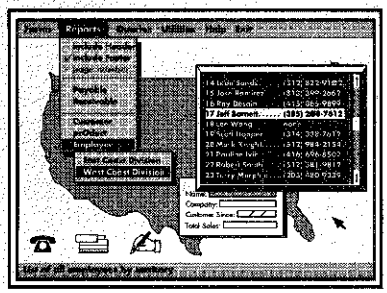

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for the hardware to perform these functions. In write mode 1, the read places the data in the latches and then sends it back to the video RAM. This means that the data bypasses the hardware. Because the EGA/VGA does not care about these registers, you can omit all references to them, decreasing code size and improving speed.

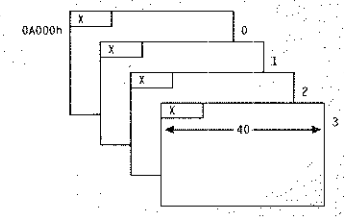
The move routines do have some drawbacks. Because you are only copying data in write mode 1, the data you want to display must already exist somewhere in the video RAM. Additionally, the disregard for register settings precludes masking portions of bytes or shifting the data by pixel increments.

To use the write mode 1 for icon display, you must store the data somewhere in video RAM. The **Display_Icon** routine (see Listing 1) copies an icon from system RAM and then stores it in video RAM. **Display_Icon** takes as parameters the addresses of the icon data, horizontal byte, and vertical scan line. **BytesPerLine** stores the number of bytes per line, because video RAM can be remapped (as discussed in the previous article). The test program uses video mode 13, 320 × 200 × 16 colors, which defaults **BytesPerLine** to 40.

WHICH FORMAT FOR YOU?

Selecting the icon data format that best suits your video mode is as important as choosing the routines that display icons on the screen. To determine the most efficient layout, you must know the layout of the video RAM for the mode you are using. Figure 1 shows the layout for

FIGURE 1:Video RAM layout for EGA mode 13



Mode 13(0dh) (40 bytes per line). One bit per plane per pixel. 320 x 200 with 16 colors.

EGA mode 13; the only difference among video modes 13(0dh), 14(0eh), 16(10h), and 18(12h) is the **BytesPerLine** value. It is most practical to create icons in byte increments, because a byte copied to the video RAM represents eight pixels when the VGA controller is set up for using planes. With one byte per plane, the icon requires four bytes to represent eight pixels.

Whether you should draw the icon one plane at a time or draw all four planes one byte at a time depends on the size of your icon. The primary factor is how long it takes to toggle the Map Mask register to select different planes compared with the time it takes to add the offset to the next line. If your icon is only a few bytes wide, it is usually faster to generate it a byte at a time rather than a plane at a time. Figure 2 shows the icon formats for a 16-pixel × 1-line icon in both the byte and the plane layout methods (as well as in bytes with masking, discussed below).

FIGURE 2: Possible formats for 16-pixel x 1-pixel icon

A byte at a time

Byte 1				Byte 2			
Plane 0	Plane 1	Plane 2	Plane 3	Plane 0	Plane 1	Plane 2	Plane 3

A byte at a time with masking

Byte 1					Byte 2				
Mask	Plane 0	Plane 1	Plane 2	Plane 3	Mask	Plane 0	Plane 1	Plane 2	Plane 3

A plane at a time

Byte 1	Byte 2	Byte 1	Byte 2	Byte 1	Byte 2	Byte 1	Byte 2
Plane 0	Plane 0	Plane 1	Plane 1	Plane 2	Plane 2	Plane 3	Plane 3

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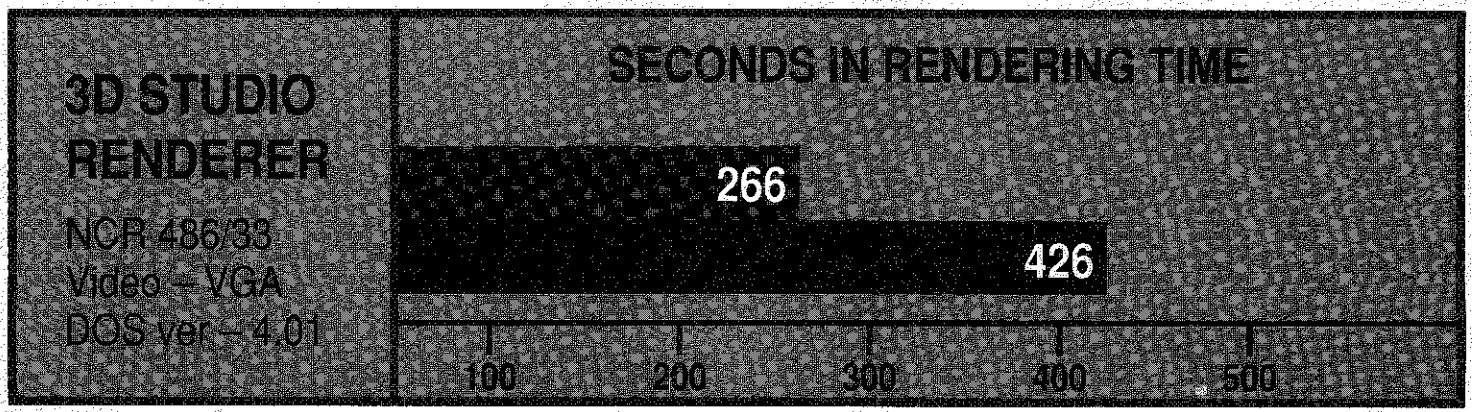

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LISTING 1

```
/* ICONDEMO.c --- a sample program for drawing and moving icons          */

#include <stdio.h>
#include <stdlib.h>
typedef char Icon[160];           /* array of 160 bytes forms an icon.  */
/* display icon at x,y from system RAM into video RAM with write mode 0 */
extern void near Display_Icon(int x, int y, void far *Data);
/* copy icon from one spot in VRAM to another spotwith write mode 1.    */
extern void near Copy_Icon(int OrigX, int OrigY, int X, int Y);
extern void near Video_Mode(int Mode) ;
extern void near Set_Pixel(int x, int y, int Color);

Icon Icon1 = {
              0x03,0x00,0x00,0x00,0x00, 0xF8,0x00,0x00,0x00,0x00,
              0x07,0x00,0x03,0x03,0x03, 0xFC,0x00,0xF8,0xF8,0xF8,
              0x0F,0x00,0x07,0x07,0x07, 0xF8,0x70,0x70,0x70,0x80,
              0x0F,0x00,0x06,0x06,0x07, 0xF8,0xF0,0xD0,0xD0,0x40,
              0x0F,0x00,0x06,0x06,0x07, 0xFC,0xF8,0xF8,0xF8,0x00,
              0x0F,0x01,0x05,0x05,0x06, 0xF8,0xE0,0xE0,0xE0,0x10,
              0x0F,0x01,0x05,0x05,0x06, 0xF8,0x70,0x70,0x50,0xB0,
              0x0F,0x01,0x01,0x01,0x00, 0xFC,0xB8,0xB8,0xB8,0x40,
              0x3F,0x00,0x00,0x0F,0x02, 0xFE,0x00,0x00,0xCC,0x0C,
              0x7F,0x00,0x00,0x3F,0x21, 0xFE,0x00,0x00,0xFC,0x0C,
              0x7F,0x00,0x00,0x33,0x30, 0xFC,0x00,0x00,0xF0,0xCC,
              0x3F,0x00,0x00,0x03,0x00, 0xFC,0x00,0x00,0xC0,0x00,
              0x3F,0x18,0x18,0x1B,0x1B, 0xFE,0x04,0x04,0xF4,0x04,
              0x7F,0x30,0x30,0x3F,0x30, 0xFE,0x0C,0x0C,0xFC,0xCC,
              0x7F,0x20,0x20,0x27,0x20, 0xFC,0x18,0x18,0x18,0x18,
              0x27,0x00,0x00,0x00,0x00, 0x18,0x00,0x00,0x00,0x00
            };
void delay(int count);

void main ()
{
    int i,j;                          /* loop variables               */

    Video_Mode ( 0x0d );       /* Step 1-set video mode to 320x200x16   */
                               /* Sets up 2 wide by 4 high memory       */
    for (j=0; j<=15; j++)      /* Step 2-manually draw the background   */
        for (i=0; i<=15; i++)  /*   icon using the Set_Pixel function   */
            if ((i+j & 1)==1)  /* Alternate pixels lt. and dk. blue     */
                Set_Pixel(i,j,1);  /* This generates the background     */
            else Set_Pixel(i,j,9); /* pattern, which you can change.    */

    for (j=0; j<13; j++)       /* Step 3-copy the icon to fill screen   */
        for (i=0; i<=19; i++)  /*   12.5 vertical is actual needed,     */
            Copy_Icon(0,0,i*2,j*16); /* the extra byte is offscreen     */

    Display_Icon(2, 90,&Icon1[0]); /* Step 4-draw icon bitmap to start  */
    Display_Icon(0,184,&Icon1[0]); /* position, draw copy for Copy_Icon */

    getch();                  /* wait for user input                    */
#define DELAY    100          /* set to your liking to slow things down */
    for (j=0; j<20*DELAY; j += DELAY) {   /* add our little delay loop  */
        Copy_Icon(2,90,37,90);    /* redraw the background area we use  */
        for (i=2; i<38; i++) {    /* Step 5-do some animation with icon */
            Copy_Icon(0,184,i,90);      /* copy icon to the new position */
            Copy_Icon(0,  0,i-2,90);    /* overwrite trailing w/bkg      */
            delay(j);                   /*    and gradually slow it down */
        }
        Display_Icon(0,184,&Icon1[0]); /* draw a new copy for Copy_Icon */
   }
    getch();                  /* wait for user prompt                   */
    Video_Mode ( 3 );         /* restore to text mode before exiting    */
};

void delay(int count) {       /* our delay function to slow things down */
    while (count--)
        srand(0);             /* use any function for delay             */
}
```

LISTING 2

```
; ICONTOOL.ASM -- EGA/VGA Icon Drawing
; set up for C style calling method for routines
; these routines are currently set up to use a near call model
; by Peder Jungck, Copyright 1991
;
DATA  segment byte public 'DATA'
DATA  ends

_TEXT  segment byte public 'CODE'
       assume     cs:_TEXT, ds:DATA, es:nothing;

Public _Copy_Icon              ;(int OrigX, int OrigY, int X, int Y);
Public _Display_Icon           ;(int x,int y,void far *Data);
Public _Video_Mode             ;(int Mode);
Public _Set_Pixel              ;(int x,int y,int Color);

BytesPerLine  dw  40           ; screen width in bytes (320x200 Mode)
VOffset       equ 0a000h       ; video RAM offset

Display_IconParms struc
                dw     2 dup(?) ; pushed BP and return address
    pp_xpos     dw     ?
    pp_ypos     dw     ?
    pp_pointer  dw     ?
Display_IconParms ends
_Display_Icon proc near    ; _Display_Icon(int x, int y, void far *Data);
        push    bp
        mov     bp,sp
        push    ds
        push    di
        push    si

        mov     ax,VOffset              ; EGA address
        mov     es,ax                   ; segment ega

        mov     ax,BytesPerLine         ; RAM line length currently set
        xchg    di,ax                   ; BytesPerLine to DI
        lds     si,[bp+pp_pointer]      ; ds:[si]=start of icon

        mov     ax,word ptr [bp+pp_ypos] ; get vertical line
        mul     di

        mov     bx,word ptr [bp+pp_xpos] ; horizontal byte
        add     bx,ax                   ; (y*40) + bx <- horiz byte
                                        ; normally in wm0

        dec     di                      ; next line offset variable
                                        ; adding at position 2 in icon
                                        ; to end up at position 1 in
                                        ; next line of icon in video RAM
        mov     dx,03c4h                ; select the map register
        mov     al,2
        out     dx,al

        mov     cx,16                   ; number of lines per icon
DIStrt: mov     dx,3ceh
        lodsb                           ; get the mask
        mov     ah,8
        xchg    ah,al
        out     dx,ax
        mov     dx,03c5h                ; load map register data addr
        mov     al,1                    ; plane 1
        out     dx,al
        lodsb
        xchg    es:[bx],al

        mov     al,2                    ; plane 2
        out     dx,al
        lodsb
        xchg    es:[bx],al

        mov     al,4                    ; plane 4
        out     dx,al
        lodsb
        xchg    es:[bx],al

        mov     al,8                    ; plane 8
        out     dx,al
        lodsb
        xchg    es:[bx],al

        inc     bx                      ; column 2
        mov     dx,3ceh
        lodsb.                          ; get the mask
        mov     ah,8
        xchg    ah,al
        out     dx,ax

        mov     dx,03c5h                ; load map register data addr

        mov     al,1                    ; plane 1
        out     dx,al
        lodsb
        xchg    es:[bx],al
```

continued

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```
        mov     al,2                    ; plane 2
        out     dx,al
        lodsb
        xchg    es:[bx],al

        mov     al,4                    ; plane 4
        out     dx,al
        lodsb
        xchg    es:[bx],al

        mov     al,8                    ; plane 8
        out     dx,al
        lodsb
        xchg    es:[bx],al

        add     bx,di                   ; start of next line of icon
                                        ; in video RAM
        loop    DIStrt                  ; do next row

        mov     al,0fh                  ; reset the map mask
        out     dx,al
        mov     dx,3ceh
        mov     ax,0ff08h               ; reset bit mask to all ones
        out     dx,ax

        pop     si
        pop     di
        pop     ds
        pop     bp
        ret
_Display_Icon endp
Copy_IconParms struc
                dw      2 dup(?) ; pushed BP and return address
    CIOx        dw      ?
    CIOx        dw      ?
    CIx         dw      ?
    CIy         dw      ?
Copy_IconParms ends

_Copy_Icon proc near ; Copy_Icon(int OrigX, int OrigY, int X, int Y);
        push    bp
        mov     bp,sp
        push    si
        push    di
        push    ds

        mov     ax,VOffset              ; EGA address
        mov     es,ax                   ; segment ega
        mov     ds,ax                   ; segment for ega

        mov     ax,word ptr [bp+CIOy]   ; get origination icon addr
        mul     BytesPerLine            ; get vertical line

        mov     si,word ptr [bp+CIOx]   ; horizontal byte
        add     si,ax                   ; (y*40) + bx <- horiz byte

        mov     ax,word ptr [bp+CIy]    ; get vertical line
        mul     BytesPerLine

        mov     di,word ptr [bp+CIx]    ; horizontal byte
        add     di,ax                   ; (y*40) + bx <- horiz byte
                                        ; normally in wm0

        mov     dx,03c4h
        mov     al,02
        out     dx,al

        mov     dx,03c5h                ; load map register data addr

        mov     al,0fh                  ; enable all planes
        out     dx,al

        mov     dx,3ceh
        mov     al,5
        out     dx,al
        inc     dx
        mov     al,1
        out     dx,al                   ; select write mode 1

        mov     ax,BytesPerLine         ; offset to next line
        dec     ax                      ; subtract icon width
        dec     ax

        mov     cx,16
CIStrt: movsb   ; reads ds:[si] then writes es:[di]
        movsb   ; reads icon place in memory then writes to dest

        add     si,ax                   ; get to start of next line of
        add     di,ax                   ; the orig and dest addresses
        loop    CIStrt

        mov     dx,3cfh                 ; write mode register already
        mov     al,0                    ; selected, just output value
        out     dx,al                   ; restore write mode 0

        pop     ds
```

continued

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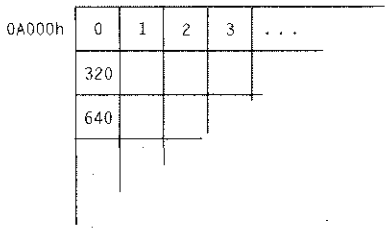
Masking is a useful feature that you can build into your icon display routines. Using masking, you are not bound to rectangular objects even if your data forms a rectangular block. An additional byte is needed to store the parts of the icon that are clear for every eight pixels. When masking is used, the byte-at-a-time display method is most effective: you can load the Bit Mask register (Port 3ceh, function 8) and then copy the four planes to the video RAM without having to modify the register. If you were using the plane-at-a-time method, you would have to modify the Bit Mask register for each byte displayed and calculate an offset into a table in order to retrieve these masks. **Display_Icon** uses the byte-at-a-time method with the masking added in (see Figure 2).

Figure 3 shows the layout for VGA mode 19 (13h), in which memory is laid out as one contiguous block with one byte per pixel. Because in this mode you don't need to worry about blocks being eight pixels, you can make the icons any size without affecting their layout design. In this mode I recommend laying out the icon pixel by pixel, from left to right and top to bottom. Instead of adding mask information to your icon, you can implement masking by selecting one of the 256 colors as your mask color. Because you are displaying a pixel at a time, don't display this color if you come across it. This will result in an instant mask.

FIGURE 3: Layout for VGA mode 19 (13h)



Mode 19 (13h) (320 bytes per line). One byte per pixel, one plane only. VGA only 320 x 200 with 256 colors.

The sample application generates fixed-size icons that are 16 pixels square: 2 bytes by 16. Each byte (eight pixels) needs a byte for each plane plus one byte for the Bit Mask. Thus, 2 bytes wide × 5 data each × 16 lines yields 160 bytes per icon. A predefined icon is included in the source to be used with the **Display_Icon** routine. The background is generated by a pixel pattern drawn in the shape of an icon used with the **Copy_Icon** routine. The displayed icon is also used as the source for **Copy_Icon** calls. The sample application displays a dithered background and then animates an icon across it.

Icons can open up the world of animation. Simply generate multiple icons of an image in different positions and then place one over the other in sequence. Or go a step beyond and redraw what was behind an icon before drawing the next. Most commercial products that feature animation use the latter technique in combination with page flipping and off-screen drawing to achieve the smooth-moving sequences that characterize them. PJ

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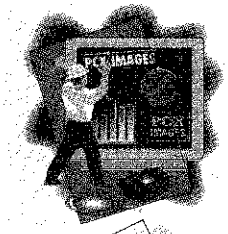

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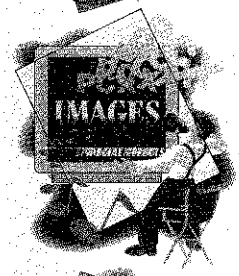

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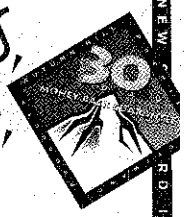

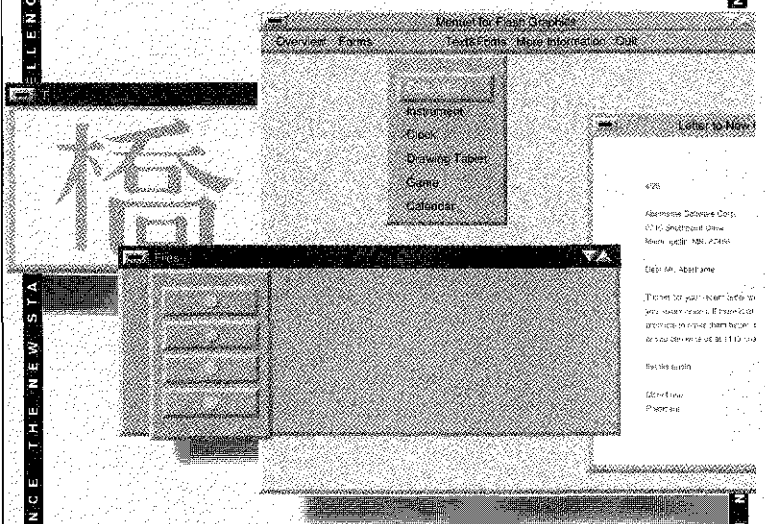

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```
        pop     di
        pop     si
        pop     bp
        ret
_Copy_Icon endp

Video_ModeParms struc
                dw      ?       ; pushed BP
                dw      ?       ; return address pushed by call
    vm_mode     dw      ?       ; pass new video mode parameter
Video_ModeParms ends
_Video_Mode     proc    near    ; void Video_Mode(int Mode);
        push    bp
        mov     bp,sp           ; put sp in bp, to get parameters on stack
        mov     ax,word ptr [bp+vm_mode]
        xor     ah,ah           ; set video mode ( ah=0 )
        int     10h             ; call video BIOS
        pop     bp
        ret
_Video_Mode endp

Set_PixelParms          struc
                dw      ?       ; pushed BP
                dw      ?       ; return address pushed by call
    ps_xpos     dw      ?
    ps_ypos     dw      ?
    Color       dw      ?
Set_PixelParms          ends
_Set_Pixel proc near            ; void Set_Pixel(int x, int y, int Color)
        push    bp
        mov     bp,sp
        push    ds              ; save the data segment
        mov     ax,YOffset      ; get the video RAM address
        mov     ds,ax           ; set data segment to EGA/VGA
        mov     ax,[bp+ps_ypos] ; get the y coordinate
        mul     BytesPerLine    ; get the offset to line y
        mov     bx,[bp+ps_xpos] ; get the x coordinate
        mov     cx,bx           ;  and save in CX too
        shr     bx,1            ;  and divide by 8
        shr     bx,1
        shr     bx,1
        add     bx,ax           ; bx := BytesPerLine*y+(x/8)
                                ; we now have x,y memory offset
        and     cl,7            ; generate mask for one pixel in byte
        xor     cl,7
        mov     ch,1
        shl     ch,cl           ; ch := 1 >> (7-(x mod 8))

        mov     dx,3ceh         ; now select write mode 2
        mov     al,5
        out     dx,al           ; select mode (register 5)
        mov     dx,3cfh
        mov     al,2
        out     dx,al           ; and set to write mode 2

        mov     dx,3ceh         ; set up mask
        mov     al,8
        out     dx,al           ; select mask (register 8)
        mov     dx,3cfh
        mov     al,ch
        out     dx,al           ; set mask

        mov     al,[bx]         ; read from card and color dot
        mov     ax,[bp+Color]
        mov     [bx],al         ; write color to dot

        mov     dx,3ceh         ; restore default mode
        mov     al,5
        out     dx,al           ; select mode (register 5)
        mov     dx,3cfh
        mov     al,0
        out     dx,al           ; set write mode back to 0
        mov     dx,3ceh
        mov     al,8
        out     dx,al           ; select mask (register 8)
        mov     dx,3cfh
        mov     al,0ffh
        out     dx,al           ; and set default mask
        pop     ds              ; restore data segment
        pop     bp
        ret
_Set_Pixel      endp

_TEXT ends
end
```

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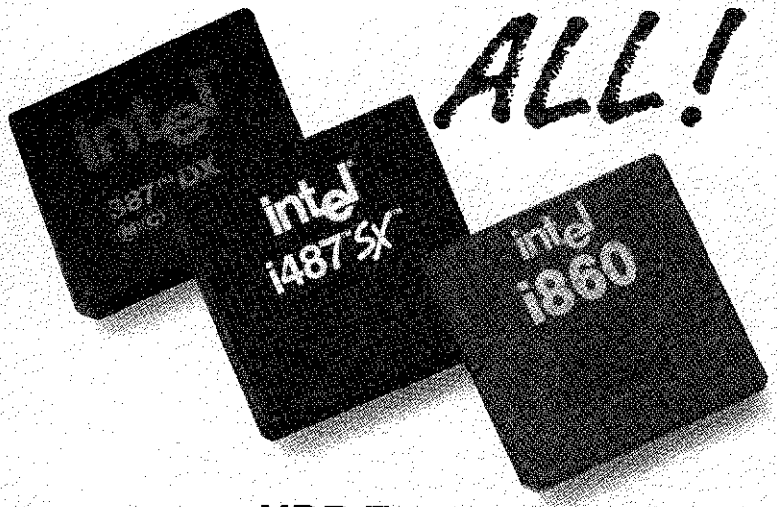

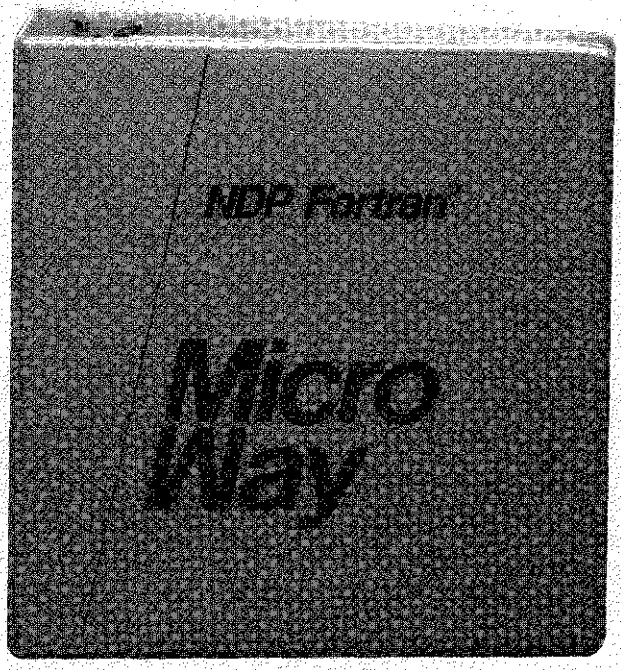

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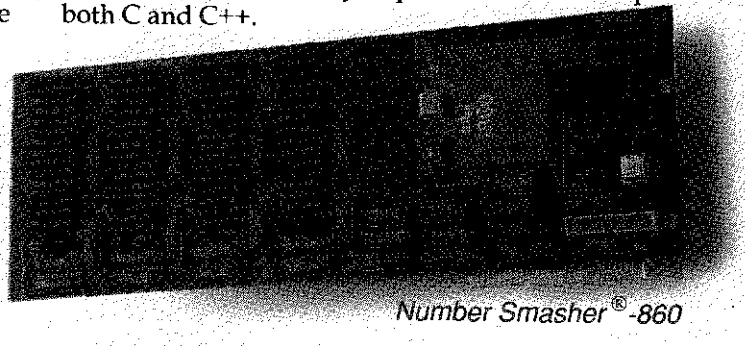

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Integrate Divide and conquer

Examining math coprocessors for the 80386 and 80486

By Mark J. Barrenechea

Historically, floating-point arithmetic has been slower than similar integer-based arithmetic. That's why designers have used numeric processing units as separate execution devices. Floating-point comparisons, for example, can be expensive: on an 80386, it is faster to do floating-point comparisons in the integer unit than in the floating-point unit. But as the 80x86 has evolved, so has the coprocessor, and the performance gap between the floating-point and integer units has narrowed so much that the differences are negligible. This narrowing has been caused by advances in silicon technology, improved microcode, and the increased amount of software logic contained in hardware.

INTEGRATION IS THE WAY

The emerging trend of the nineties is to integrate the traditional integer and numerics units on a single chip. The increasingly crowded and clouded numerics market currently includes the i486DX, SPARC, MIPS R2000/3000/4000, RS6000, and i860 chips. Unlike their pedantic, clunky predecessor, the Intel 80386, these newer chip designs have highly coupled execution units.

For the Intel 80386, the math coprocessor market is straightforward and well defined. The best-known coprocessors are the Intel 387, the Cyrix EMC87, the Cyrix 83D87, and the Weitek 3167. (Two lesser-known products are not reviewed here, but vendor information is provided below.) Two coprocessors are available for the 80486: the Weitek 4167 and the Intel 487 (which is a 387 bundled with the 486). The 387 is not bundled with the 486SX.

This article explores the chip technology and performance of the "divide and conquer" approach taken by the Intel 80386/80486 and its math coprocessors. Each math coprocessor will be discussed in terms of its design issues and features, and benchmarks will be run to compare like results.

A MATTER OF MAPPING

There are two physical approaches to attaching a coprocessor inside a PC: I/O mapping and memory mapping. The Intel 387/487 and Cyrix 83D87 are I/O mapped. The Weitek 3167/4167 is memory mapped. The Cyrix EMC87 works in either mode, but Cyrix recommends that modes not be mixed.

In I/O mapping, the coprocessor is linked to the 80386 by a direct connection over the I/O bus. A memory-mapped coprocessor uses a memory address range to communicate with the 80386.

I/O-mapped math coprocessors are directly connected to the 80386. (Another term for this class of coprocessor is *387-compatibility mode.*) The coprocessor recognizes any instruction that is prefaced by an appropriate ESCAPE sequence; no memory addresses are set aside for special purposes such as instruction encoding. I/O-mapped coprocessors use I/O port addresses that are inaccessible to the programmer. These 32-bit addresses have their high-order bit set (0x80000000) [Reference 1].

Because the 80386 CPU and its math coprocessor have separate execution units, in theory the two units can "coprocess"—that is, execute instructions in parallel. The drawback is that handshaking and synchronization cycle delays can offset the gains made by scheduling. Instruction scheduling is an underused optimization for I/O-mapped math coprocessors (see my article, "Peak performance: On to the 80486," *PJ* 8.6).

Mark J. Barrenechea is vice-president of language development at MicroWay, Inc., in Plymouth, Massachusetts.

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Intel has defined the I/O-mapped architecture well, as evidenced by the number of alternative 387-compatible math coprocessors and floating-point emulation libraries that exist today.

AN EXPLANATION IS DUE

Memory-mapped coprocessors require more explanation because of their clever design. The *Weitek WTL1167 Software Design Guide* [2] provides a good overview of how memory-mapped coprocessors work. Some of that information follows.

When the 80386 reads from memory, it emits signals on its control output pins, along with the actual memory address on the address pins. Figure 1 shows how an 80386 and a memory device interact: the device uses the upper bits of the address to determine whether or not to activate. When it does activate, the middle and lower address bits are used to determine which memory cells are accessed. The device responds by sending the value of a memory cell over the 80386 data bus, where it can be accessed by the 80386.

The 80386 CPU communicates with memory devices via this message passing. This device does not have to be a memory device, however; it can be a coprocessor that is activated when a certain address range is accessed (read or written). At the hardware level, a memory-mapped coprocessor masquerades as a memory device. At the software level, it operates as a math coprocesser (see Figure 2).

The numbers show that memory-mapped coprocessors do, in fact, outperform I/O-mapped coprocessors.

Both the Weitek 3167/4167 and the Cyrix EMC87 require a 121-pin extended math coprocessor (EMC) socket on the 80386 motherboard. The larger sockets are necessary to accommodate these memory address lines for the memory-mapped coprocessors.

Even though memory-mapped coprocessors cannot coprocess with the 80386, in theory they should execute faster because they communicate via memory, not the I/O bus. I/O-mapped coprocessors move data and instructions over multiple cycles, whereas information can be exchanged in one cycle (a write to memory) for memory-mapped coprocessors. The numbers show that memory-mapped coprocessors do, in fact, outperform I/O-mapped coprocessors.

Memory-mapped math coprocessors do not have well-defined interfaces. Each chip manufacturer can design its own address ranges, instruction encoding, and structural details. The lack of a uniform interface is illustrated by the assembly code that is necessary to drive the Cyrix EMC and Weitek 3167/4167 (see below).

FIGURE 1: Interaction of the 80386 and a memory device

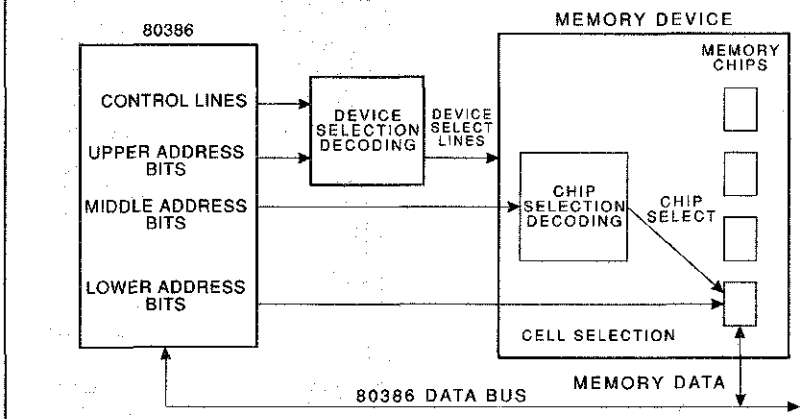
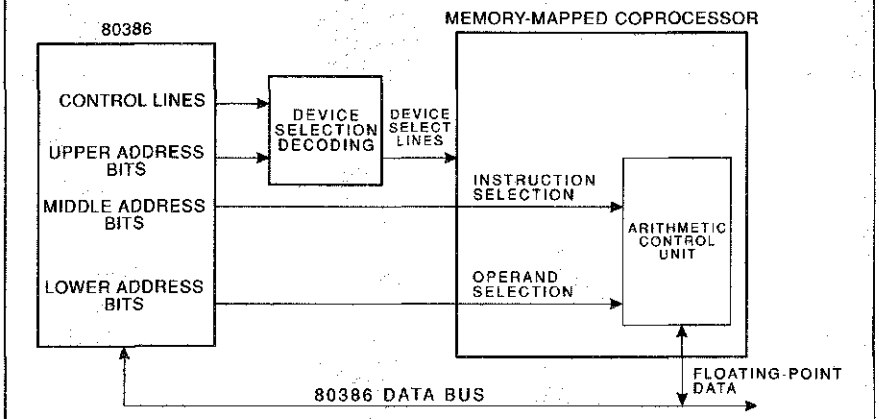


FIGURE 2: The 80386 with a memory-mapped coprocessor



THE PLAYERS

The Weitek 3167/4167 provides a register set of 32 32-bit single-precision registers. These can be doubled up, making 16 64-bit double precision registers. The use of register R0 is restricted, but this doesn't affect the application programmer. Unlike the Intel 387/487 and Cyrix 83D87, the 3167/4167 does not support 80-bit extended reals.

The Weitek coprocessors have traded accuracy for speed. As with the i860, certain features of the IEEE standard are not implemented. Additionally, denormal arithmetic is not performed; all denormals are flushed to zero.

The Weitek 3167/4167 features an interesting instruction set. One instruction, the multiply accumulate, can

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be used to generate high-speed matrix manipulation:

```
wfmac     ws17, ws5 ; ws2 = (a11 * x) + (a21 * y)
wfmac     ws18, ws6 ; ws2 = (a11 * x)
          + (a21 * y) + (a31 * Z)
wfmac     ws19, ws7 ; ws2 = (a11 * x)
          + (a21 * y) + (a31 * Z) + (a41 * w)
```

This instruction set has important implications when one of the benchmarks is applied.

Consider the following C program:

```
extern float f1;
extern float f2;
float foo(voidv ){
  return ((f1 + f2) * (f1 - f2));
  }
```

Listing 1 shows the generated Weitek 3167/4167 assembly language code. Note that the Weitek macros (**wfld, wfadd, wfneg,** etc.) and 386 instructions are provided. The memory move instructions that are typical of a memory-mapped coprocessor,

```
; wfld ws4,dword ptr ds:_f1
  mov  eax,dword ptr ds:_f2
  mov  dword ptr ds:[000000010H],eax
```

access a range of memory that activates the Weitek to load a single-precision register, **ws4,** with the value of **f1.**

From a functional standpoint, the Cyrix EMC is 100% compatible with the 387. It has only eight registers and an internal 80-bit register format. If a compiler already generates 387 code, the Cyrix EMC intercepts the 387 instructions and substitutes the EMC memory-mapped equivalent. A single 387 instruction can (and usually does) generate multiple EMC instructions. The EMC code in Listing 2 is functionally equivalent to the C program given above.

The Intel 387 is a stack-based math coprocessor whose instruction set is currently popular. The 387 instructions generated from the C program are provided in Listing 3.

THE BENCHMARKS

Because a coprocessor may have special high-speed instruction sets for handling a particular problem (transcendentals, matrix operations, scalars, multiply accumulates, 3-D rendering, etc.), a good floating-point benchmark must allow coprocessors to be tested in real-world applications. The WhetStone benchmark is not perfect, but it has a reasonable mix for testing math coprocessors that work with the 80386 and 80486. It contains scalar floating-point code, transcendental code, and matrix operations.

TABLE 1: Benchmark results, single precision (KWhets/sec)

Coprocessor	WhetMat	WhetScal	WhetTrans	WhetStone
386:				
Cyrix 83D87	851	1445	2217	5075
Cyrix EMC87	1848	4050	3557	7934
Weitek 3167	2699	4332	1582	6719
Intel 387DX	849	1492	910	3800
486:				
Weitek 4167	5967	12995	4238	15148
Intel 487DX	2460	3876	1610	7934

TABLE 2: Benchmark results, double precision (KWhets/sec)

Coprocessor	WhetMat	WhetScal	WhetTrans	WhetStone
386:				
Cyrix 83D87	711	1389	2890	4673
Cyrix EMC87	1186	3570	4427	6757
Weitek 3167	1120	3804	1570	5378
Intel 387DX	713	1339	1039	3509
486:				
Weitek 4167	2783	10756	3951	12995
Intel 487DX	2263	3651	1734	7577

MicroWay has broken out the standard WhetStone into three separate benchmarks: WhetMat (the matrix operation), WhetScal (the set of floating-point scalar operations), and WhetTrans (the transcendentals). Listing 4 shows the subroutines for each benchmark. Each piece was run in single and double precision.

The WhetStone benchmark is not perfect, but it has a reasonable mix for testing math coprocessors that work with the 80386 and 80486.

The WhetStone benchmark can also be used to test parameter-passing speeds. On a RISC device, this test can be significant. It is not significant on modern CISC architectures, where function calling is negligible and a good function in-liner can remove the call altogether.

When it is "rating" a coprocessor, a benchmark can represent two aspects: the coprocessor's performance in a given floating-point arena and the compiler's ability to recognize and generate optimal code sequences. If a compiler cannot generate matrix operations for a given coprocessor, the matrix instructions are unused or untested, thus underrating the coprocessor's ability. This was taken into consideration when these benchmarks were run.

TEST RESULTS

The 80386 results were generated on an AIR 386AS motherboard, with 64K of cache, using an Intel 80386 33-MHz processor and 8MB of main memory. All coprocessors were 33 MHz. NDP-386-FORTRAN 3.2.0 was used.

The 80486 results were generated on a MicroWay NumberSmasher 486-ISA burst-mode motherboard with no cache. All other conditions were the same.

MicroWay NDP-FORTRAN can generate highly tuned code for each of these benchmarks and coprocessors. Thus, the numbers in Tables 1 and 2 represent an accurate measure of apples to apples—a solid mix of compiler ability and coprocessor features (this benchmark could have been written in C, C++, or Pascal), and, if transliterated

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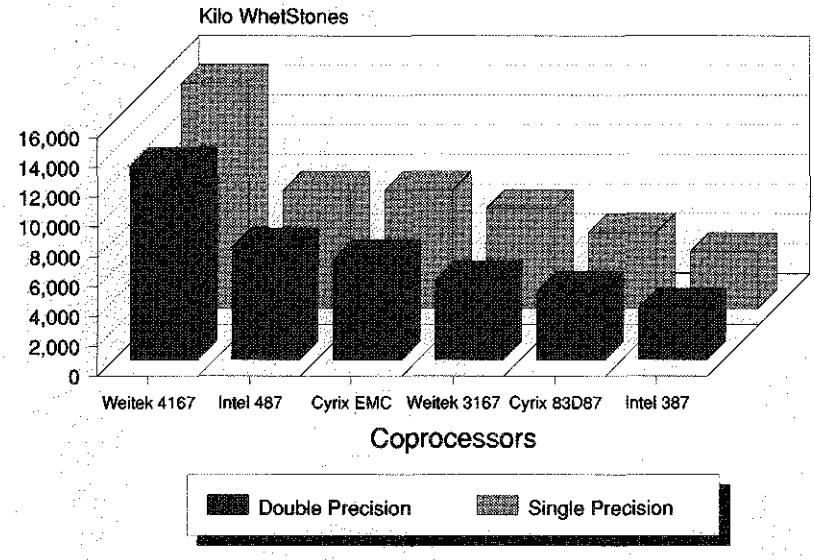
correctly, the numbers that were generated would have been the same as the Fortran equivalent. The two tables show the single- and double-precision results, respectively. The best rating in each category is highlighted. Figure 3 presents the overall WhetStone rating and compares single- and double-precision results.

It is easy to see that the competition for top chip is between Weitek and Cyrix. The Intel 387 and 487 perform relatively slowly in each of their respective categories. Any discussion centered on performance must exclude them.

On the 80386 in single precision, the Weitek wins in WhetMat (matrix operations), because it has a special high-speed multiply accumulate for matrix operations. The Weitek and Cyrix EMC are fairly close in WhetScal (scalar arithmetic), although the Weitek wins. In WhetTrans, the Cyrix EMC is the clear winner; it's highly tuned with specialized microcode to do very fast

FIGURE 3: Coprocessors for the 80386/80486



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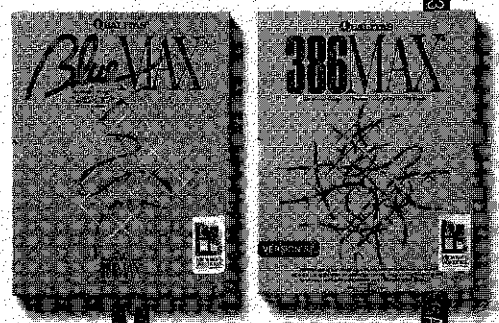

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LISTING 1

```
_foo    proc    near

        mov     eax,dword ptr ds:_f1
        mov     dword ptr ds:[000000410H],eax

;       wfld    ws4,dword ptr ds:_f1
        mov     eax,dword ptr ds:_f2
        mov     dword ptr ds:[000000010H],eax

;       wfadd   ws4,dword ptr ds:_f2
        mov     eax,dword ptr ds:_f2
        mov     dword ptr ds:[000002808H],eax

;       wfneg   ws2,dword ptr ds:_f2
        mov     eax,dword ptr ds:_f1
        mov     dword ptr ds:[000000008H],eax

;       wfadd   ws2,dword ptr ds:_f1
        mov     byte ptr ds:[000000888H],al
;       wfmul   ws2,ws4
        ret
        align   4

_foo    endp
        extrn   _f2:dword
        extrn   _f1:dword
        public  _foo
        end
```

LISTING 2

```
_foo    proc    near
        push    ebp
        mov     ebp,esp
        sub     esp,16
;       fld     dword ptr ds:_f2
        mov     eax,dword ptr ds:_f2
        mov     dword ptr ds:[512],eax
;       fsubr   dword ptr ds:_f1
        mov     eax,dword ptr ds:_f1
        mov     dword ptr ds:[160],eax
;       fst     dword ptr [ebp]+(-16)
        mov     eax,dword ptr ds:[576]
        mov     dword ptr [ebp]+(-16),eax
;       fld     dword ptr ds:_f2
        mov     eax,dword ptr ds:_f2
        mov     dword ptr ds:[512],eax
;       fadd    dword ptr ds:_f1
        mov     eax,dword ptr ds:_f1
        mov     dword ptr ds:[0],eax
;       fst     dword ptr [ebp]+(-12)
        mov     eax,dword ptr ds:[576]
        mov     dword ptr [ebp]+(-12),eax
;       fmulp   st(1),st
        mov     dword ptr ds:[3364],eax

;       fstp    dword ptr [ebp]+(-8)
        mov     eax,dword ptr ds:[608]
        mov     dword ptr [ebp]+(-8),eax
        mov     edx,[ebp]+(-8)
        mov     [ebp]+(-4),edx

;       fld     dword ptr [ebp]+(-4)
        mov     eax,dword ptr [ebp]+(-4)
        mov     dword ptr ds:[512],eax
        leave
        ret

        align   4

_foo    endp

        extrn   _f2:dword
        extrn   _f1:dword
        public  _foo

        end
```

LISTING 3

```
_foo    proc    near
        push    ebp
        mov     ebp,esp
        sub     esp,16

;       .bf:    ;
        fld     dword ptr ds:_f2
        fsubr   dword ptr ds:_f1
        fst     dword ptr [ebp]+(-16)
        fld     dword ptr ds:_f2
        fadd    dword ptr ds:_f1
        fst     dword ptr [ebp]+(-12)
        fmulp   st(1),st
        fstp    dword ptr [ebp]+(-8)
        mov     edx,[ebp]+(-8)
        mov     [ebp]+(-4),edx

;       .ef:    ;
        fld     dword ptr [ebp]+(-4)

       leave
        ret

        align   4

_foo    endp

        extrn   _f2:dword
        extrn   _f1:dword
        public  _foo

        end
```

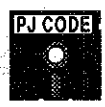
LISTING 4

```
      SUBROUTINE WHETMAT
      DIMENSION  A(140,140), B(140,140), C(140,140)
C        ...
      DO 5 I = 1, 100
         DO 5 J = 1, 100
            A(I,J) = 50 * I + J
            B(I,J) = 77/J + 11/I
            C(I,J) = 0.0
    5 CONTINUE
      END



      SUBROUTINE WHETTRANS
      DO 78 I=1, N7, 1
         X = T*ATAN(T2*SIN(X)*COS(X)/(COS(X+Y)+COS(X-Y)-1.0))
         Y = T*ATAN(T2*SIN(Y)*COS(Y)/(COS(X+Y)+COS(X-Y)-1.0))
   78 CONTINUE
C        ...
      DO 118 I=1,N11,1
         X = SQRT(EXP(LOG(X)/T1))
  118 CONTINUE
      END


      SUBROUTINE WHETSCAL
      X1 = 1.0
      X2 = -1.0
      X3 = -1.0
      X4 = -1.0
C        ...
      DO 18 I =1, N1, 1
         X1 = (X1+X2+X3-X4)*T
         X2 = (X1+X2-X3+X4)*T
         X4 = (-X1+X2+X3+X4)*T
         X3 = (X1-X2+X3+X4)*T
   18 CONTINUE
      END
```



All code in this issue is available through our bulletin board services or directly from PJ on disk. For information see page 81.

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transcendentals. The overall single-precision winner on the 80386 is the Cyrix EMC, by 18%.

On the 80386 in double precision, the Weitek is in catch-up mode. The Cyrix EMC wins the WhetTrans, the WhetMat, and the overall WhetStone. Even more impressive than the EMC's winning both the single- and double-precision benchmarks is its ability to perform better in double-precision transcendentals than single-precision by 24%. This means programmers get greater precision and accuracy in less time. Cyrix obviously did its homework in this area.

On the 80486, the Weitek 4167 beats the Intel 487 in *all* single- and double-precision tests. The Weitek 4167 does, however, lose to the Cyrix 386 EMC in double-precision transcendentals by 12%. Again, the Cyrix EMC transcendentals fly. On the 80486, the Weitek 4167 is the clear winner.

It's interesting to observe that a 386 with an EMC87 is competitive with an Intel 486/487 on scalar code and far superior on transcendentals.

CONCLUSION

If you wanted a math coprocessor for the 80386 three years ago, you had two choices: an Intel 80387 or a Weitek 3167. Today, you have more than six choices. In a year, you will have at least eight—Chips & Technologies and AMD will be entering this already crowded market. Wall Street analysts say that the 387DX is the highest-profit-margin chip ever produced by Intel, and the other manufacturers are obviously trying to grab a share of this profit center. The 80387 has carried a retail price of almost 50 times the manufactured cost of about $20. The 80486 choices (the Intel 487 and the Weitek 4167) are where the 80386 choices were three years ago.

The competition among chips can be profitable for some and deadly for others. As the math coprocessor industry evolves, chip manufacturers are subject to natural selection. When I began this article, the Intel 387DX-33 was selling for more than $500. It has now dropped to less than $200. (Because of such fluctuations, prices are not listed with the product information.) It's hard to predict which coprocessors will emerge as the fittest.

The fastest math coprocessor at any given moment is king of the hill. Currently, the Cyrix EMC is enjoying this reign on the 80386, and the Weitek 4167 on the 80486. But watch out—no one knows where the chips may fall.

REFERENCES

1. Intel Corporation (1987). *80387 Programmer's Reference Manual*, pp. 2-6.
2. Weitek Corporation (1987). *Weitek WTL1167 Software Design Guide.*

VENDOR INFORMATION

Cyrix EMC87 and Cyrix 83D87
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Circle **216** on Reader Service Card

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Window layers

Part 3: How a large window and a small viewport can work together

By Allen Holub

This article describes the high-level part of a windowing function library that combines the text-buffer and viewport manipulation routines from two previous articles (*PJ* 9.1, 9.4) into a useful windowing system. (The low-level component will be covered in an upcoming issue.) Windows can be created, destroyed, hidden, and moved in the usual way; but a window can also be large, with only a small viewport into the underlying text displayed on the screen. Moving the window cursor to an area of the undisplayed underlying text causes the text to slide under the viewport until the appropriate text comes into view.

OUT FOR A VIDEO SCROLL

Before starting in earnest, I need to make a few minor corrections to the previous articles. In my last article (9.4), I forgot to describe and include the code for one of the viewport functions, which is included on this issue's code disk:

```
int v_scroll_region( viewport *v,
                     int up, int to_left,
                     int left, int top, int right,
                     int bottom )
```

This function scrolls the text in the viewport horizontally or vertically (or both), but only that text bounded by the box given in the four last arguments is scrolled. (These are window-relative row and column numbers.) The text is moved up by **up** lines, and it's moved **to_left** lines to the left. The opened-up regions are filled with spaces. The **up** and **to_left** arguments may be zero, and they may also be negative. The text moves to the right if **to_left** is negative; it moves down if **up** is negative. The cursor position is not changed by the scroll. This function may not be used to clear the viewport—if the requested movement is greater than the viewport dimension, **v_scroll_region** returns false (and no movement occurs along that axis). Use **v_clear** to clear a viewport. The function also returns false if the bounding box is outside the window. (In such cases it truncates the size of the bounding box to fit).

The **v_scroll** function that was included last time is actually a macro in VIEWPORT.H that looks like this:

```
#define v_scroll(v,u,l) v_scroll_region  \
        ((v),(u),(l),0,0, VMAXCOLS,VMAXLINES)
```

I also found a few bugs and omissions in the previous code. In TEXTBUF.H (Listing 1, *PJ* 9.1) you need a backup macro to complement **b_advance(b)**:

```
#define b_backup(b) ( (b)->col--, (b)->p-- )
```

This macro backs up the cursor one notch. I've also changed the name of the **b_setrc** macro to **b_gotorc** so that its name agrees with the **v_gotorc** macro used for viewport management.

In addition to the **b_clearline** function that I described in *PJ* 9.1, it turned out to be handy to have a **b_cleartoeol,** which clears from the cursor to end of line. It looks like this:

```
#define b_cleartoeol(b,c) \
    bufset((b)->p, (c), (b)->ncols - (b)->col)
```

This function matches the viewport's **v_cleartoeol(v)** function (in V_CLEAR.C on the code disk).

I've added another function to the buffer-management items (shown in Listing 1). This function, **b_last(textbuf *b)**, returns the column number of the rightmost nonwhite column on the current line.

Finally, the **b_delete** macro (from 9.1's Listing 1) had a bug in it. The new version is as follows:

```
#define b_delete_c(b,n,c) (  bufmove( (b)->p, \
        (b)->p+(n), (b)->ncols -((b)->col+(n))), \
                bufset ( ( (b)->p - (b)->col) + \
                ( (b)->ncols - (n) ), (c), (n)) )
```

AN ARCHITECTURE OF LAYERS

Let's take a look at the system within which windows function. Three layers are involved in any given window. At

---

Allen Holub is a teacher, writer, consultant, and composer. He teaches C and compiler design for the U.C. Berkeley Extension. His most recent book is Compiler Design in C. *Allen can be reached at holub@violet.berkeley.edu (...!ucbvax!violet!holub) via USENET or c/o Software Engineering Consultants, P.O. Box 5679, Berkeley, CA 94705.*

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the top is the viewport—the portion of the window that's displayed on the screen (viewports are covered in *PJ* 9.4). This viewport is a window, so to speak, into a larger text buffer that resides in memory. The text buffer is, in turn, a window into a much larger underlying file. That is, the text buffer holds some limited number of lines from the file, and the viewport holds some limited number of lines and columns from the text buffer. The buffer and the file are the same width—the maximum line width is the same in both layers. The viewport can be narrower than the buffer, but not wider.

A provision is also made for adding a built-in editor to the window. The functions, as presented here, are all low-level: move the cursor, print a character, and so forth. Ideally, these functions could be buried inside an "editor" function that would make the actual window calls. Looked at in an object-oriented fashion, the user interface would get a stream of editor directives from the input system. Some of these (such as standard characters) would represent an "insert a character here" directive to the editor. Other characters (such as function keys) would do cut operations, move the cursor long distances, and so forth. This stream of characters can be thought of as a string of "messages" that are passed to an editor object. The editor would then call the low-level window functions to do the actual work.

The viewport is a window into a larger text buffer in memory. The text buffer is a window into a larger underlying file.

The editor object, however, needs a structure of some sort to store its own internal state. It can't use global variables for this purpose, because several windows, each with its own editor, might be active. Similarly, the window functions need a structure to keep track of their states (current cursor position, relative position of the viewport with reference to the underlying text, and so forth). You could pass two pointers to the editor functions, which would then pass the window-structure-pointer back to the windowing workhorse functions. But it's easier to pass just one pointer.

You could accomplish this in C++ by creating an editor class and then deriving the window class from it:

```
class editor
{   // Editor state data
    // and functions
}
class window : public editor
{   // Window state data
    // and functions
}
```

You could then pass a pointer to a **window** through to an **editor,** and everything would work without difficulty.

In C, you have to simulate derivation by nesting the editor structure inside the window structure, like this:

```
struct editor
{
    /* editor state */
};
struct win
{
    struct editor e;
    /* window state */
};
```

Because the **editor** is at the top of the **win**, a pointer to a **win** structure will also point at the nested **editor** structure. (I use **win** instead of **window** because Borland has used that word for something else.)

WORKHORSE FUNCTIONS

To make the system as general-purpose as possible, the editor defines a set of functions that it needs to do its work—functions that move the cursor, print characters, delete characters, and so forth. This editor can then be used in virtually any environment simply by providing the required functions. The lowest-level loop would look like this:

```
make_editable_window
{
    win *w;
    w = open_window;
    while( getchar != EOF )
        editor( c, w );
    close_window;
}
```

The **w** pointer is passed to the editor function, which treats it as if it were a pointer to an **editor** structure. This allows you to have several windows, each with its own editor. The editor function calls the window workhorse functions. Because the **editor** pointer is also a **win** pointer, the editor can pass the incoming pointer back down to the workhorse functions, which manipulate the **win** component of the structure. The window functions don't manipulate the **editor** component, and the editor functions don't manipulate the **win** component.

These workhorse functions can be used independently, of course. The editor object is a good conceptual tool, but your program could just as easily call the low-level window functions directly. Nonetheless, I've designed hooks for the editor into the current functions and data structures so that an editor can later be added easily; I'll discuss this in detail next time.

GETTING MORE CONCRETE

The definitions for this system are split into two files. The first, WINDOW.H (Listing 2), holds definitions that are used to manipulate windows at a higher level. The **win** structure represents the window. It starts with an **editor**, as promised. The editor definition is in the header file TOOLS/EDITOR.H (available on this issue's code disk), which will be discussed next time. The preceding **#define ETYPE struct win** customizes the definitions in EDITOR.H to the current application. EDITOR.H contains function prototypes for the low-level functions that the editor needs to do its work, and these functions are passed an **ETYP** first argument in the prototype:

```
int  e_open( ETYP *const p );
```

The real functions, however, are declared with a **win** first argument, like this:

```
int  e_open( win *const p ){...}
```

The macro maps **ETYP** into the correct type.

The next fields are the **viewport** and **textbuf** for the window. The **row_off** and **col_off** fields hold the distance from the upper-left corner of the text buffer to the upper-left corner of the viewport, thus positioning the viewport with respect to the text buffer. **file_off** does the same thing with the text buffer and the underlying file. It's the distance (in lines) from the top line of the file to the top line of the text buffer. The **bottom** field holds the line number of the bottom

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line of the file. The cursor position is not permitted to go past this position.

The various **update_** fields are used to disable viewport updating. This is handy when, for example, you want to write to a hidden window. These fields hold the offsets and cursor position that were current when updating was disabled. The cursor is restored to this position when updating is reenabled. An application program can modify or search around in the underlying buffer to its heart's content, and the old position will be restored when updating is reenabled.

The **update** and **dirty** fields are also used here: **update** is false when viewport updating is disabled. The **dirty** bit is set true if the text buffer has been modified, rather than just examined, since updating was disabled. If the buffer is clean, this preempts an unnecessary screen refresh. **engine_active** is another hook for editing-engine support. It's set true after the engine is initialized.

FOUR FILE MANIPULATORS

The four function pointers at the bottom of the structure take care of underlying-file manipulation. If they're NULL, then there is no underlying file. Otherwise, they work as follows. The

```
char *(*import)(
        struct win *this, int lnum );
```

function is used to get lines from the underlying file. It is passed a line number and returns a string that holds that line from the file. The

```
int   (*insert)(
        struct win *this, int lnum );
```

function inserts a blank line at the indicated position in the file. The original contents of that line, and all lines beneath it, are moved down one notch. The

```
void  (*export)(
        struct win *this, int lnum, char *line,
        int nc, int len );
```

function is the opposite of **import**. It is used to copy a modified line from the text buffer to the underlying file and is passed the number of the line to overwrite, the contents (**line**), the size of the line buffer (**nc**), and the number of characters actually used in the **line** string (**len**).

The function

```
void  (*remove)(
        struct win *this, int lnum,
        char *line, int nc, int len );
```

complements **insert**. It deletes the indicated line from the file and moves everything beneath it up a notch to fill the gap. It's passed the same information as **export** so that it can save the deleted line for a possible **undo** operation.

The easiest way to manage a file is with an array of **long**s that's indexed by line number and that holds the byte offset from the base of the file to the first character of the indicated line. A delete and insert can manipulate this array. A read goes to the file and simply reads in the line. A write is a bit more complicated, because the lines are probably not all the same length. The best approach is to put the actual text of the overwritten line at the end of the file, rather than trying to insert it into the file itself. You can then overwrite the beginning-of-line pointer in the array with the offset to the

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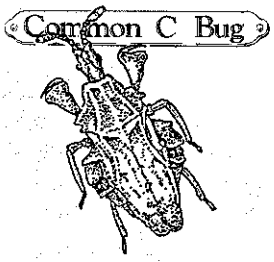

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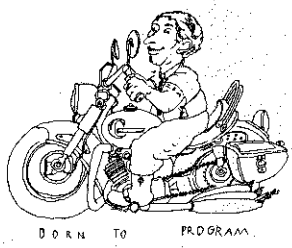

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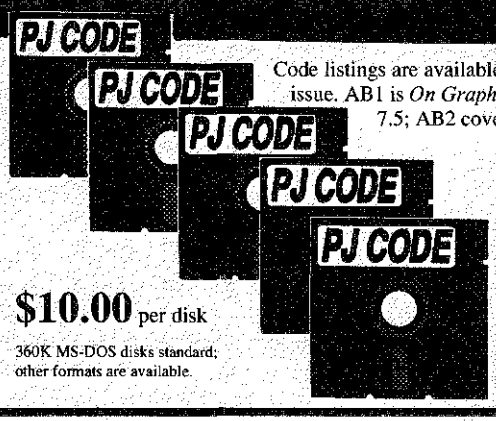

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new (rather than to the original) text. An occasional "garbage collection" pass can go through the array and create a second file that contains only the active lines (the ones with pointers to them in the array). It then replaces the current file with the new one and adjusts all the pointers to hold the correct offsets. The Unix vi editor does this every time a **write** operation is performed.

You can also store a copy of your array of **longs** in the file. This lets you recover a file if a power failure (or some other catastrophic error) occurs in the middle of an editing session. Also note that the "file" need not be a real file—it can be on a RAM disk or in extended or expanded memory. This can save considerable time when you do reads, writes, or refreshes.

BYPASSING THE EDITOR

The rest of WINDOW.H contains function prototypes for those window functions that aren't used by the editor. Listing 3 demonstrates how these functions can be used for a simple editor/window application.

The call to

```
win *w_construct (int win_height,
                  int win_width );
```

creates the window structure, initializing the underlying buffer to the indicated height and width. The window is not displayed, however. Various window attributes are modified as necessary.

```
void w_viewsize( win *w,
                 int view_height, int view_width );
```

modifies the viewport size from its default (the entire window) to the indicated height and width.

```
void w_viewcolor ( win *w,
                   int foreground, int background );
```

modifies the foreground and background colors from the defaults (light gray background, black foreground). The possible colors are defined in Borland's CONIO.H file. Next,

```
void w_move( win *w, int row, int col );
```

moves the viewport's position on the screen from the default (banged up against the upper-left corner) to the indicated row and column. The upper-left corner is (0,0). **w_move** can be called at any time to move the window around on the screen. The

```
void w_file( win *w, ... );
```

call attaches file-manipulation subroutines to the window so that an underlying file can be accessed. If you don't call this routine, then the window functions assume that no underlying file exists.

Finally,

```
void w_open( win *w );
```

actually displays the window on the screen.

When the function is finished with the window, a call to

```
void w_destroy( win *w );
```

removes it from the screen, restoring the underlying text and freeing all memory associated with the window. The text buffer is also flushed to disk at this time.

The remaining high-level functions include

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```
#if PROTOTYPES
    double sqrt (double);
#else
    double sqrt ();
#endif

main ()
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```

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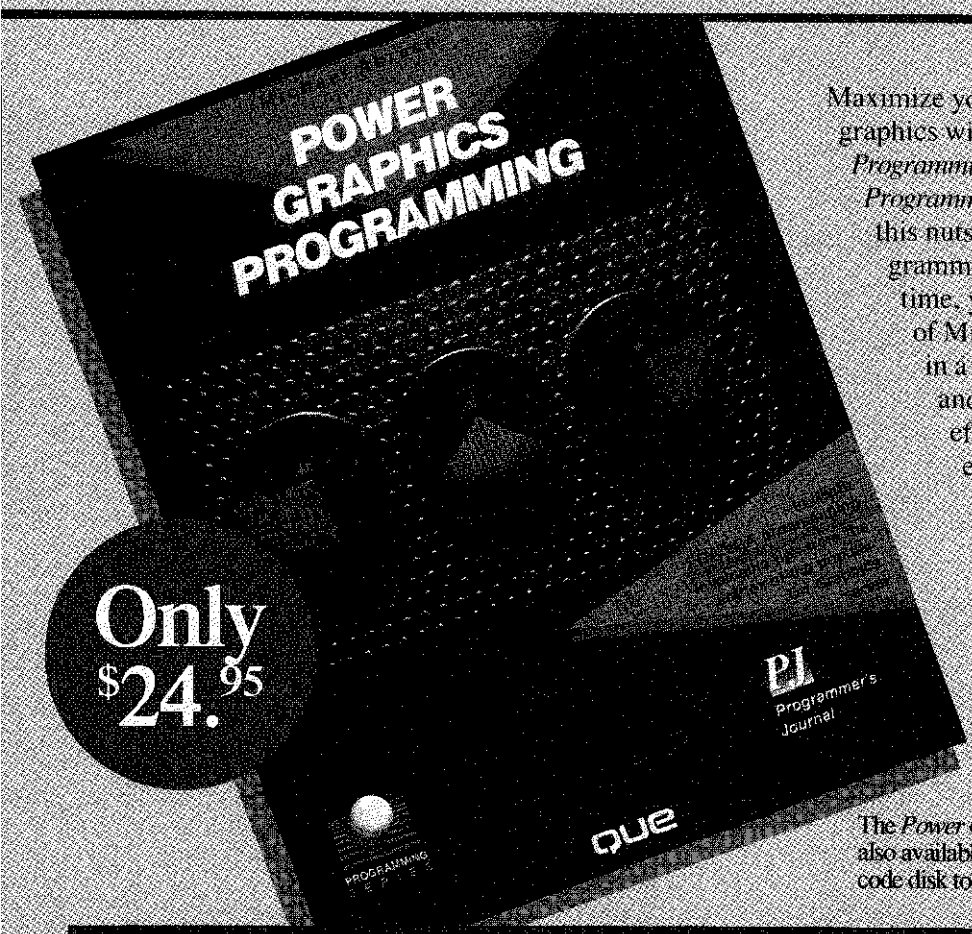

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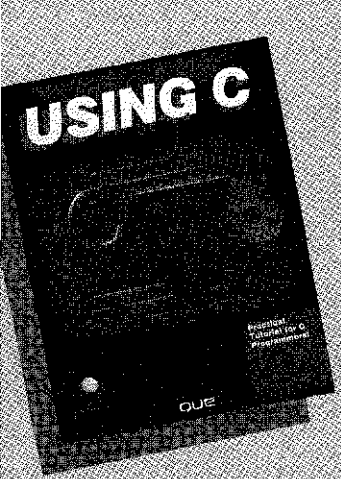

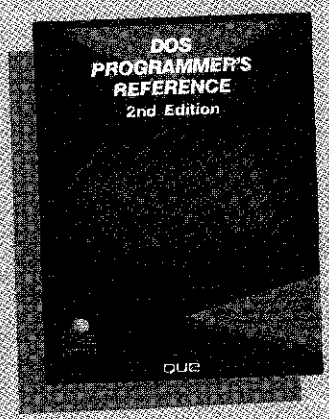

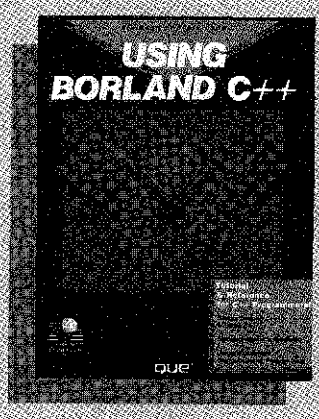

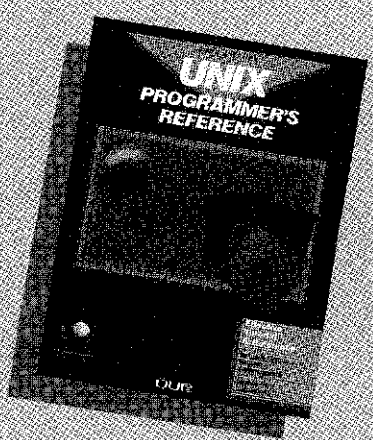

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```
void w_hide( win *w );
```

which hides the window (makes it vanish from the screen) without destroying it. You can write to a hidden window, or you can move it. Redisplay it with another **w_open** call. The

```
void w_move_rel( win *w,
        int delta_row,
        int delta_col );
```

moves the viewport relative to the current position on the screen rather than to an absolute position. A negative **delta_row** goes left; a negative **delta_col** goes up.

The final function prototype is for

```
void wputc( win *w, int c );
```

There is no **wputc** in the current article, but the prototype allows you to add one. The most basic **wputc** simply passes characters to the editing engine as they come in from the keyboard.

All these functions are declared in WINDOW.C (Listing 4).

CONCLUSION

So that's all for now. This powerful windowing system has the potential to let you manipulate huge text buffers that are stored in files through a tiny viewport on the screen. Next time, I'll provide windowing support for the editor. The main deficiency in the current implementation is error checking, which could be improved. You could also expand the window concept considerably, implementing such things as boxed windows and subwindows. (When you move a window, all the subwindows move with it. This is useful if you're using small windows to implement fields in a larger screen.) Even so, I hope you find the functions provided here helpful as they stand. PJ

LISTING 1

```
/* b_last.c-- Find Last Character on Line */
#include <tools/textbuf.h>

b_last( textbuf *b )
{
    bufptr startp = b->buf + (b->ncols * b->row);
    bufptr endp   = startp + (b->ncols);
    while( --endp > startp && isspace(*endp) )
        ;
    return( endp - startp );
}
```

LISTING 2

```
/* window.h-- High-Level Window Definitions */
#ifndef __WINDOW_H
#define __WINDOW_H

#include <tools/textbuf.h>      /* textbuf definition.  */
#include <tools/viewport.h>     /* engine definition.   */

#define ETYP struct win
#include <tools/editor.h>       /* Customize editor.h prototypes  */
                                /* for use in a window.           */
#define W_LINEMAX E_LINEMAX     /* This can be eliminated if      */
                                /* not using an editor layer.     */
typedef struct win
{
    editor e;           /* Variables for engine maintenance       */
                        /* This would be the base class in a C++  */
                        /* implementation. THIS MUST BE AT        */
                        /* THE TOP OF THE STRUCTURE BECAUSE IT'S  */
                        /* USED POLYMORPHICALLY BY THE EDITOR.    */
                        /* This can be eliminated if you're not   */
                        /* using an editor layer.                 */
    textbuf  b;         /* Text buffer and viewport.              */
    viewport v;         /* (instance variables, not base classes) */

    unsigned row_off;  /* Offset to upper-left corner of textbuf   */
    unsigned col_off;  /*        to upper-left corner of viewport  */
    unsigned file_off; /* Offset from top of file to top of buffer.*/
                       /* Initially zero, incremented on a success-*/
                       /* ful import when text scrolls up. Decre-  */
                       /* mented on import when text scrolls down. */
                       /* I'm assuming that text is positioned     */
                       /* initially at the top of the file, so     */
                       /* it's an error if you try to scroll text  */
                       /* down and file_off==0.                    */
    int bottom;        /* Line number of bottom line in file. -1   */
                       /* if the file is empty.                    */

    unsigned update_row_off;  /* Position when screen updating is  */
    unsigned update_col_off;  /* disabled                          */
    unsigned update_file_off;
    unsigned update_row;
    unsigned update_col;

    unsigned update : 1; /* Viewport updating is enabled.          */
    unsigned dirty  : 1; /* File modified when updating disabled.  */
    unsigned error  : 1; /* Error has occurred at some point.      */

    unsigned engine_active : 1; /* Editing engine initialized      */

    char *(*import)(struct win *this,int lnum );
    int   (*insert)(struct win *this,int lnum );
    void  (*export)(struct win *this,int lnum,char *line,int nc,int len);
    void  (*remove)(struct win *this,int lnum,char *line,int nc,int len);
}
win;

win *w_construct ( int win_height, int win_width );
void w_destroy   ( win *w );
void w_open      ( win *w );
void w_hide      ( win *w );
void w_viewsize  ( win *w, int view_height, int view_width );
void w_viewcolor ( win *w, int foreground, int background );
void w_move_rel  ( win *w, int delta_row, int delta_col );
void w_move      ( win *w, int row, int col );
void wputc       ( win *w, int c );
void w_file      ( win *w,
    char *(*import)( win *this,int lnum ),
    int   (*insert)( win *this,int lnum ),
    void  (*export)( win *this,int lnum, char* line,int nc,int len),
    void  (*remove)( win *this,int lnum, char* line,int nc,int len)
                );
#endif /* __WINDOW_H */
```

LISTING 3

```
/* wintest.c-- Test main() for Window-Based Editor */
#include <stdio.h>
#include <conio.h>      /* Borland video defines (RED, CYAN, etc.) */
#include <tools/window.h>

/* Hooks for the file manager. Fill these in if you want an       */
/* underlying file. If not, remove the w_file() call in main().  */

#pragma argsused
static void sigexport( win *this, int line_number, char *line,
                                                int ncols, int len)
{
}

#pragma argsused
static char *sigimport( win *this, int line_number )
{
    static char line[128];
      return line;
}

#pragma argsused
static void sigremove(win *this,int line_number,char *line,
                                                int ncols, int len)
{
}

#pragma argsused
static int  siginsert( win *this, int line_number )
{
}
```

continued

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```
#define WINSIZE  20     /* 40x40 text buffer */
#define VIEWSIZE 10     /* 10x10 viewport    */

void main()
{
    static int c;
    static win *w;

    w = w_construct(   WINSIZE,  WINSIZE        );
    w_viewsize      (w, VIEWSIZE, VIEWSIZE      );
    w_viewcolor     (w, RED, CYAN               );
    w_move          (w, 1  , 1                  );
    w_file          (w, sigimport, siginsert, sigexport, sigremove);
    w_open          (w );

    while( (c = getch()) != 'q' )
           wputc( w, c );
    w_destroy( w );
}
```

LISTING 4

```
/* window.c-- High-level Window Functions */
#include <stdio.h>
#include <stdlib.h>
#include <conio.h>
#include <tools/window.h>

void wputc( win *w, int c );    /* Test function in wputc.c */

#include <conio.h>              /* Debugging stuff          */
#include <dos.h>

static int Instance_count = 0;

win *w_construct( int win_height, int win_width )
{
    win *w;
    if( !(w = malloc(sizeof(win)) ) )
        return NULL;

    if( ++Instance_count == 1 ) /* Creating first window        */
        v_startup( C4350 );     /* Start up video system.       */

    w->row_off  = 0;    /* Viewport in upper left corner of     */
    w->col_off  = 0;    /* the buffer.                          */
    w->file_off = 0;    /* No lines above window in file        */
    w->bottom   = -1;   /* No lines read yet                    */
    w->import   = NULL; /* No overflow file by default.         */
    w->export   = NULL;
    w->remove   = NULL;
    w->insert   = NULL;
    w->engine_active    = 0;    /* engine not initialized       */
    w->update           = 0;    /* updating is disabled         */
    w->update_row_off   = 0;    /* when updating is enabled,    */
    w->update_col_off   = 0;    /* set cursor to top left of    */
    w->update_file_off  = 0;    /* viewport, buffer, and file.  */
    w->update_row       = 0;
    w->update_col       = 0;
    w->dirty            = 0;

    /* Create text buffer and viewport */
    b_construct  ( &w->b, win_height, win_width );
    v_construct  ( &w->v );
    v_saveok     ( &w->v, 1 );
    v_clearok    ( &w->v, 1 );
    v_size       ( &w->v, win_height, win_width );
```

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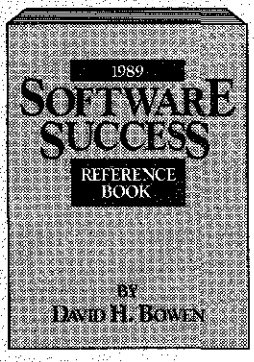

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```
    v_foreground ( &w->v, BLACK        );
    v_background ( &w->v, LIGHTGRAY    );
    return w;
}
void w_destroy( win *w )        /* Destroy the window */
{
    v_destroy  (&w->v);         /* Destroy the viewport          */
    b_destruct (&w->b);         /* Destroy the text buffer       */
    free( w );                  /* Free the space for the window */
    e_close( w );               /* Flush buffer to underlying file */
    engine_close( w );          /* Shut down the editor.         */
    if( --Instance_count == 0 ) /* Destroyed the last window.    */
        v_shutdown  (   );      /* Shut down the video system.   */
}
void w_open( win *w )
{
    v_open  ( &w->v );          /* Display the viewport          */
    e_update( w, 1  );          /* Enable writes to the window   */
                                /* and position cursor at (0,0)  */
    if( !w->engine_active ){    /* Edit engine is uninitialized. */
        e_open( w );            /* Initialize buffer             */
        engine_open( w );       /* Initialize edit engine.       */
        w->engine_active = 1;   /* Mark it as initialized.       */
    }
}
void w_hide( win *w )
{
    e_update( w, 0 );           /* Disable viewport updating.    */
    v_deactivate( &w->v, 1 );
}
void w_viewsize( win *w, int view_height, int view_width )
{
    v_size( &w->v, view_height, view_width );
}
void w_viewcolor( win *w, int foreground, int background )
{
    v_foreground ( &w->v, foreground  );
    v_background ( &w->v, background  );
}
void w_move_rel( win *w, int delta_row, int delta_col )
{
    /* Move delta_row rows down and delta_col columns to the right. I'm
     * assuming that the window's hidden if updating is off. This might
     * not be the case, though. If this assumption causes problems, add
     * a "hidden" attribute to either the viewport structure
     * (preferable) or the win structure (less preferable, but it will
     * work). If you do the former, provide a v_visible() that
     * evaluates true if the viewport is visible. */

    if( !w->update )
        v_move_rel( &w->v, -delta_row, -delta_col );
    if( w->update )
    {
        w_hide( w );
        v_move_rel( &w->v, -delta_row, -delta_col );
        w_open( w );
    }
}
void w_move( win *w, int row, int col )
{
    /* Move delta_row rows down and delta_col columns to right */
    if( !w->update )
        v_move( &w->v, row, col );
    else {
        w_hide( w );
        v_move( &w->v, row, col );
        w_open( w );
    }
}
void w_file( win *w,
        char *(*import)( win *this, int lnum ),
        int  (*insert)( win *this, int lnum ),
        void (*export)( win *this,int lnum,char *line,int nc,int len),
        void (*remove)( win *this,int lnum,char *line,int nc,int len)
      )
{
    /* Attach file-level support to the window functions. */
    w->import   = import;
    w->insert   = insert;
    w->export   = export;
    w->remove   = remove;
}
```


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Pursuing systems programming

By M. Steven Baker

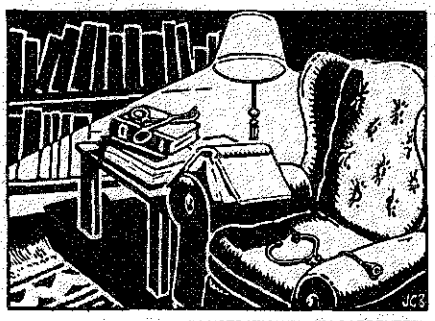

ILLUSTRATION BY JIM CARPENTER

Challenging problems have always attracted me, so over the years I've been drawn to systems programming—first under CP/M-80 and then in the DOS environment. These days a PC programmer might need fluency in the Mac world, the 386 Unix market, and on workstations (aka Sun). Considering the vast array of add-on hardware and ever-changing system software, there's still a great demand for systems programming. This time around I'll review some newer books that cover PC systems programming, and I'll cross over onto the other turf—that of the VAX world and the big IBM mainframes.

THE NEW DOS ARRIVES

In the past, the PC community has depended on IBM to provide technical reference manuals on PC hardware and DOS system software. But with Windows and DOS 5, IBM is no longer the only source of information for DOS software. Fresh from the printer, the ***Microsoft MS-DOS Programmer's Reference,*** from Microsoft Press, is a technical reference for DOS 5. Written by Microsoft staff, this book covers superseded features from earlier DOS versions, but its real value is its coverage of the new DOS.

The book starts with an introduction and overview of DOS, including chapters on the DOS file system, character input and output, program management (resources, memory, TSRs, etc.), and national language support. The bulk of the book is the last three chapters (appendices in earlier IBM DOS manuals), which discuss DOS interrupts (other than INT 21h), the INT 21h functions, and device drivers. Appendices cover code pages, extended key codes, and error values.

This official DOS 5 reference manual makes a modest break from the past by documenting some previously undocumented DOS features. For example, you'll find brief information on the interrupts that TSR programs depend on. These include INT 28h (DOS idle handler), INT 21h function 32h (**get InDos flag**), and DOS's **ErrorMode** flag. The book covers several of the DOS multiplex interrupt handlers (INT 2fh functions) as well as the new task-switching and memory-allocation features, system calls, and other new functions. For example, DOS 5 has a new **get version** call (INT 21h called with AX = 3306h) that returns the actual DOS version, because the DOS 5 SETVER utility allows you to fool a program. This call also returns a revision number and indicates whether DOS is in the high memory area or is running from ROM. If you want to take full advantage of DOS 5, this reference is mandatory.

Abacus has a valuable programmer's resource in ***PC System Programming,*** by Michael Tischer (1990). An in-depth reference for DOS programmers, this rather massive book is divided into five parts: an overview of PC components; DOS; BIOS; PC hardware; and the interaction among keyboard, BIOS, and DOS. Large appendices provide detailed reference to DOS and BIOS functions. Some undocumented DOS features are well illustrated. For programmers, this book's advantage is its combination of DOS, BIOS, and hardware coverage in a single volume, profusely illustrated with useful example code. The discussion of DOS is solid, and the chapters covering the ROM BIOS and PC hardware are especially strong.

The book's two companion disks include all the sample source programs in BASIC, C, Pascal, and assembly language. If you're looking for a routine to explore floppy diskettes directly or to reprogram the AT real-time clock, then this book is for you.

YOUR MOUSE, OR MINE?

Another new arrival is Microsoft Press's second edition of their ***Microsoft Mouse Programmer's Reference.*** This edition—an overview and technical reference manual for programmers on the Microsoft mouse—adds coverage of the new functions added in version 8.0 of the Microsoft mouse driver (some calls were added with the 7.05 driver). These new mouse functions (functions 37–52) add support for acceleration curves, virtual coordinates, changing video modes, ballpoint mice, initialization, and hardware reset. Conveniently, mouse function 50 returns a 16-bit flag with a bit set for each advanced function that the driver supports (starting with function 37). The book provides function call examples in interpreted BASIC, QuickBASIC, C, and assembly language, with some interface examples for Fortran and Turbo Pascal. Also discussed are the Microsoft mouse menu language and the MOUSE.LIB EGA interface. Two disks are included, with sample programs written in BASIC, C, Fortran, Pascal, and assembly language.

With IBM planning a fall marketing blitz, OS/2 is receiving renewed attention. One of the better books on OS/2 graphic interface programming is ***OS/2 Presentation Manager Programming Primer,*** by Asael Dror and Robert Lafore (Osborne McGraw-Hill, 1990). This introduction to PM programming is divided into four parts: an overview, the user interface, graphics and text, and advanced topics. The section on the user interface has a competent discussion of windows, messages, controls, resources, menus, and dialog boxes, but the strongest chapters are those on graphics and the OS/2 GDI. The authors also illustrate the use of the clipboard, multitasking, and foreign language support. The book is heavily laced with example OS/2 source code

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in C (which is available on disk from the authors). This is the best book I've found on the subject of OS/2 PM graphics programming.

UNIX AND BEYOND

An interesting older (1987) book from Prentice-Hall is ***Operating Systems: Design and Implementation,*** written by Andrew Tanenbaum. Although most books on operating systems are long on theory, this book tries to balance theory and practice. The author examines the fundamental concepts—including process management, memory management, input/output, and the file system—in reasonable detail. But the focus is on MINIX, a Unix-compatible operating system. MINIX supports the same system calls as the older Version 7 of Unix; a complete, heavily commented source code listing of MINIX is provided for study. You'll find both detailed discussion and source code examples that illustrate process management, interprocess communication, message passing, scheduling algorithms, semaphores, deadlocks, memory management, paging algorithms, file system design, input/output, device drivers, security and protection mechanisms, and more.

In addition to Tanenbaum's book, Prentice-Hall sells versions of MINIX on disk with manuals for the IBM PC, Mac, Atari ST, Amiga, and SPARC. Along with the kernel, MINIX includes a Unix-compatible shell, utility programs, and a C compiler. These disk versions include the complete source code for the operating system as well as all the utilities except the C compiler and assembler.

Most operating systems, particularly Unix, are moving to comply with Posix—an ANSI standard under development that defines an operating system interface for C programs. ***The Posix.1 Standard: A Programmer's Guide,*** by Fred Zlotnick (Benjamin Cummings, 1991), explains the syntax and semantics of the 200+ C functions and macros covered in the Posix.1 standard and the data structures that support them. These data structures include process and system attributes, process creation and synchronization, files and directories, I/O, signals, controlling terminals, and data interchange formats. Offering detailed discussion, C function prototypes, and example code, the book is well organized and easy to read.

Wiley's ***Berkeley UNIX: A Simple and Comprehensive Guide,*** by James Wilson (1991), provides a compact introduction to the user and programming interfaces for Berkeley Unix. The book is divided into three sections: Unix commands and user interface, shell programming, and the C programming interface. Both the Bourne and the C shell are modestly covered. I found the chapters on creating multiple processes (forks), pipes, signals (interrupts), and interprocess communications (sockets) to be most valuable. Each chapter includes short examples to illustrate the concepts discussed. If you need a reader-friendly introduction to forks, signals, and sockets, I highly recommend Wilson's *Guide.*

IT'S A MAINFRAME WORLD?

If I'm at all typical, many a PC programmer still has one foot in the minicomputer/mainframe world, whether they want to or not. If you also occasionally work on big IBM iron (IBM 360/370/390, etc.), the third edition of ***System 370/390 JCL,*** by Gary Brown (Wiley, 1991), is an excellent resource. IBM mainframe operating systems are a world unto themselves, and the official IBM manuals aren't very useful. This book provides comprehensive and easy-to-read coverage of IBM's Job Control Language (JCL) on the MVS operating system. After a brief introduction, various JCL statements are covered in separate chapters, illustrated with short examples of usable JCL code. Brown writes with clarity and passion as he explains JCL, but he doesn't try to make you like it.

Beyond JCL, the book also examines several IBM utility programs, VSAM data sets, the linkage editor, ISPF/PDF (the IBM text editor), TSO, and TSO/REXX. The author also describes how to use the Fortran and the VS COBOL II compilers. This new edition covers the latest changes and extensions to JCL and the 390 architecture. Bound in the back is a handy quick-reference guide to JCL statements and syntax. If datasets and DD statements are getting you down, this book might provide a potent elixir. If you work on IBM mainframes, consider it an indispensable resource.

JUST THE VAX

I'd also like to mention two books for the VAX crowd. ***Mastering VMS,*** by David Bynon (Professional Press, 1990), is a solid reference on the VAX VMS operating system. For those unfamiliar with the VAX, both CP/M-80 and, consequently, many DOS utility programs and batch facilities were modeled on VMS. The first section of this book—an overview of the VAX, VMS, DECnet, and VAX clusters—is followed by chapters on VMS utilities and commands, command procedures, DECwindows, operational management, security, and performance. The VMS shell, which is VAX's powerful Digital Command Language (DCL) interpreter, is discussed in detail. The author illustrates the use of the VMS text editors (EDT, EVE, and TPU), the online HELP utility, and the MAIL and PHONE programs.

The chapters on management, security, and performance are aimed at system programmers who are responsible for maintaining a VAX system, but the information is also valuable for other programmers. The comprehensive coverage of DCL and the reference material on EDT and EVE commands make this a valuable resource for occasional VAX programmers.

Those who can find beauty in details will appreciate Digital Press's 1991 ***VAX/VMS Internals and Data Structures,*** written by Ruth Goldenburg and Lawrence Kenah. This massive tome was written by the folks from DEC who helped develop VMS. The latest edition covers the VAX/VMS version 5.2 operating system. Chapters discuss subjects such as control mechanisms, synchronization, scheduling and time support, memory management, input/output, processes, and system start-up and shutdown. As they explain VMS, the authors emphasize the data structures that are manipulated by the kernel along with the control flow of major system routines. Be forewarned: this is not light and easy bedtime fare—the index alone is almost a hundred pages long. But if you need details, this hefty volume supplies them in spades. PJ

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Thinking about project management

By William H. Roetzheim

Software can be developed either in a data processing department (or other organizational unit) that is set up in a functional organizational structure, or by using a project approach. For many organizations, especially those whose "software development" is primarily concerned with maintenance and enhancement, the additional management costs and disruptions caused by project management are neither necessary nor desirable. The decision to implement formal project management should be weighed carefully. The following questions can be used to evaluate the desirability of formal project management for your organization:

• Does the job require the integration of many components into a functioning, operational whole? The interaction between these components is best handled by a single individual who has ultimate responsibility for the project. Modular software development, by its nature, is a classic example of this type of complex interaction. Most computer hardware and systems projects have similar requirements.

• Is the job large or technically complex? Such projects usually require and deserve the close attention that management gives to the question of formal project management.

• Does management feel strongly that a single individual should be available to serve as a focal point for information and responsibility? Are tight budgetary or schedule controls necessary or desirable?

• Is the project being developed in an environment of changing requirements? If so, a project management approach will permit faster responses to changing needs and result in greater customer satisfaction.

ILLUSTRATION BY JIM CARPENTER

• Does the task require that a diverse group of professionals be brought together to work toward a common goal? Many software development projects require software professionals to work hand-in-hand with application specialists and end users. Such interactions among different groups are usually best handled in a project management environment.

Although the decision to use formal project management should not be automatic, most software development projects are ideal candidates for this approach. Project management centralizes overall responsibility for the project in one person. The project manager is responsible for all aspects of the project, including budgeting, cost control, scheduling, resource allocation, technical quality, and customer relations. The result is a significantly higher probability of success for the development project.

THE PROJECT IS UP TO YOU

A successful implementation of the project management concept depends on the clear-cut assignment of responsibility for all aspects of the project to one individual—you. The overall outcome of the project rests solely on your shoulders. You are responsible for budgeting as well as cost control. You must schedule tasks, allocate resources (primarily people), and track project expenditures. You are responsible for the technical quality of the work and for managing client/customer and company relations throughout the project. If the project fails, all fingers will point at you.

The single most important area of responsibility is the management of customer relations. Budgeting and cost control are important, but good customer relations can allow you to obtain additional funding to compensate for a shortfall. A happy customer tends to overlook your mistakes and concentrate on your successes, but an unhappy customer is almost never pleased.

BUSINESS AND THE BEAST

Software is a strange beast. Your job as a salesperson doesn't stop when the contract is signed—it only begins. When you are done with the work, you deliver magnetic bits, fleeting images on phosphor, and words and diagrams on paper. Your customer must be convinced that these abstract items are worth their considerable cost.

Throughout the project, you must involve the customer. Give the software a personal meaning for them. When it finally works and is accepted, the victory belongs not just to the developers but to everyone involved. Your job is to determine, early in the game, what the final system will be like, given the time and money available. You must mold the customer's expectations to match the product that will be delivered. If you have made the customer feel like a team member, almost any other problem with the project can be worked out.

Let me describe a project that was brought to its knees by poor management of customer relations. A large software development organization was assigned to develop a software system to test an advanced military system. The

William H. Roetzheim is a senior associate with Booz, Allen & Hamilton, and a noted author and speaker on software engineering topics. This column is based on his book, Structured Computer Project Management *(Prentice-Hall, 1988). Bill can be contacted at Booz, Allen & Hamilton, Inc., Suite 109, 4025 Hancock Street, San Diego, CA 92110; (619) 223-5681.*

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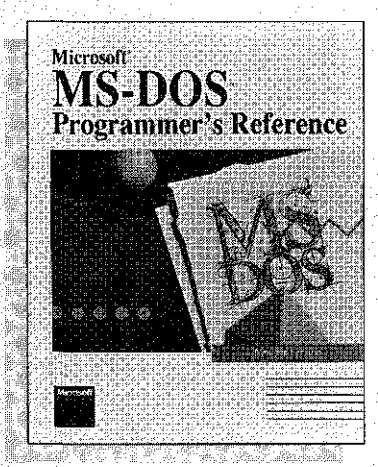

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project involved approximately $80 million worth of software, funded mostly by a joint services agency on the other side of the country. The program manager allowed a conflict-oriented relationship to develop between the project team and the customer team. The relationship deteriorated so much that the project team refused to communicate with the customer except at formal reviews (held about once a year). Instead of working with the customer's people and getting them involved in as many decisions as possible, the project manager refused to allow them even to review preliminary documents. What was the result? As you might expect, the customer used the formal reviews as an opportunity to obtain "proof" that the project team did not know what they were doing. After two years and approximately $20 million, the customer was upset enough to cancel the project outright—an almost total loss for all involved.

KEEP THE CUSTOMER POSTED

As a project manager, I once accepted a project to write a software program that would automatically monitor military tactical data links, parse the received information, and store the information in a database optimized for some tactical decision-making aids. Throughout the project, I handled critical design decisions by calling the customer, explaining the options, making a recommendation, and then following the customer's desires. Problems were explained carefully, and possible solutions were discussed. The customer was apprised of any risks as we became aware of them.

As the work progressed, it became apparent that the program would be late and over budget. We discussed this with the customer and were able to modify the requirements to allow delivery within the time and budget allowed. The project was a success both financially and in terms of customer satisfaction, all because the customer was on our team.

Once the decision has been made to use project management, it's important that every aspect of the project be given its due. Too many consultants fail to realize that careful management of customer relations can be as important as technical expertise.

Continued from Baker, page 36

it a *supervisor)* that translates the Windows 16-bit API into a 32-bit clone of Windows API for your 386 programs. Some Windows calls may overload a passed parameter as either a **long** or a **far** pointer. The supervisor layer must translate a far pointer segment:offset (32-bits) from Windows to a far pointer (48-bits) for the 386. Parameters need to be passed from this supervisor layer that Windows sees to the 386 segments that your application runs in. The challenge is making all this as transparent as possible for the developer. I can't say much in detail about these products until they're released (and I'm released from nondisclosure).

A separate DOS extender is not needed, because it is provided by Windows 3 and its DPMI services. Both MetaWare and Watcom have written a Windows virtual device driver so that their symbolic debuggers will run under Windows.

Watcom will release C/386 for Windows and FORTRAN 77/386 for Windows (call the company for current prices). MetaWare calls its product the Windows Application Developer Kit ($495), which must be purchased in addition to MetaWare's High C/386. Look for them soon.

HOT TIMES AHEAD

Theoretically, Windows should have supported being either a DPMI host or a client. However, if Windows were to run as a DPMI client, you could run all your favorite Windows apps under an OS/2 2.0 DPMI host. This would create some potential political and economic problems for Microsoft and Windows. So IBM has been left the formidable task of implementing the Windows API under OS/2 2.0.

These are exciting times for 386/486 development. Half the PCs sold today have either a 386 or 486 microprocessor. Hardware prices continue to decline. The prices of math chips (from Intel and Cyrix) have dropped dramatically. The DOS-extender market appears healthy, with many promising new products for the developer. Stay tuned for more ways to enhance this popular operating system.

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A SOFTWARE FABLE

By Richard Riehle

Once upon a time two programming teams were hired to create a new piece of software in two languages. The Hare Team selected C, and the Tortoise Team chose Ada.

The leader of the Hares said, "We can win the race, because our language is lean and easy to learn. It isn't encumbered with Ada's rules and features. The Tortoises can never catch us, because they carry that big Ada shell around on their backs."

The Tortoise team felt sad. They knew the Hares could outrun them, and it seemed hopeless even to enter the race. The Hares were half finished before the Tortoises completed the package specifications.

It was a sight to see: code poured into source files like a tidal wave into a thimble. The Hares couldn't contain their excitement, and their zeal resulted in many wonderful, unexpected new system features. Compilation was lightning fast. The Hares' system could be recompiled twice as fast as the Tortoises'.

Everyone could see that the Tortoise team didn't have a chance. And, sure enough, the Hares won the race—by three months.

Then a funny thing happened: it turned out that the race was not over after all. A year after the system was accepted, the client decided to add some new features. But many of the Tortoises and Hares had gone on to other projects, so much of the original code had to be reread and understood anew. Also, some algorithms had to be completely rewritten.

The new team of Hares picked up the C source code and began to run with it. They ran very fast indeed. But the faster they ran, the less they understood, and they found the forest of C code very thick and dark. Soon, they were lost in the forest.

The Tortoises also formed a new team. They discovered that they could easily understand the well-encapsulated packages and separate compilations. The changes were made, tested, and implemented quickly. Then the Tortoises went on to do other projects.

Meanwhile, the more the Hares tried to fix the C code, the more the forest resembled a jungle. After a very long time, the lead Hare said, "This is no use. It would be better to rewrite the whole system from scratch." A year later, the leader of the Hares took another job, the other Hares were assigned to more pressing projects, and the revisions were deemed by management as unnecessary at the costs they were incurring.

So ends the tale of the Tortoises and the Hares.

Richard Riehle is a software engineer with AdaWorks. He can be reached at 1090-105 Tanland Drive, Palo Alto, CA 94303; (415) 858-1551. *This fable may be distributed freely as long as Richard Riehle and* Programmer's Journal *are credited.*

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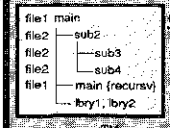

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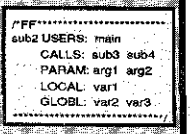

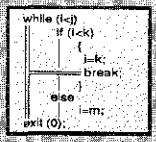

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Polyhedron Software has introduced plusFORT, a Fortran toolkit that includes tools for restructuring, reformatting, static analysis, project management, and documentation. The restructurer, based on the company's SPAG program, can be used to rewrite spaghetti logic in structured style. Declaration standardization and variable renaming are built in. License fees start at $1290.

Distributed by OTG Systems, Inc., Route 106 & 374, Clifford, PA 18413, (717) 222-9100 (for Polyhedron Software Ltd., Witney, Oxon, UK).

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QUICKPAK AND PDQCOMM

Two new products from **Crescent Software** are designed for use with Microsoft Visual Basic. QuickPak Professional for Windows provides high- and low-level facilities, communications support, windowed terminal emulations, and tutorial information. Facilities include custom controls, predefined dialog boxes, data entry routines, and financial and scientific functions. Low-level routines include array manipulation, file operations, and keyboard services. PDQComm for Windows provides routines that access multiple communication ports from within a Visual Basic application. The low-level routines in both products are written in assembly language. QuickPak Professional is $199; PDQComm is $99.

Crescent Software, Inc., 32 Seventy Acres, West Redding, CT 06896, (203) 431-4626.

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MS-DOS 5 AND PROFILER

Microsoft has released MS-DOS 5. With 80286 or higher PCs, MS-DOS 5 can reside in the HMA, providing 45K of additional memory for DOS applications and as much as 621K of free conventional memory. Users can load TSRs, device drivers, and network drivers into upper-memory blocks on 80386 and 80486 machines, freeing approximately 133K of memory. MS-DOS 5 provides a new MS-DOS Shell menu interface, which includes a file manager, program manager, task swapper, utilities, and on-line help. New utilities include undelete (retrieves deleted files) and unformat (reverses formatting on newly reformatted disks). A full-screen editor has pull-down menus and supports a mouse. Upgrading requires the presence of DOS 2.11 or later versions. MS-DOS 5 Upgrade is $99.95.

Microsoft has also released Source Profiler. This profiler supports DOS, Windows, and OS/2 platforms. It helps developers test and optimize applications written using Microsoft language products by generating data about which lines and functions are executed most often. The Source Profiler uses 80K of memory and costs $79, or $50 for registered users of Microsoft languages products.

Microsoft Corporation, One Microsoft Way, Redmond, WA 98052-6399, (800) 992-3675 or (800) 426-9400.

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F77L VERSION 5.0

F77L Version 5.0, from **Lahey Computer Systems,** is a DOS 640K Fortran language system. Version 5.0 includes multilingual compiler and runtime error messages. New statements in this Fortran 90 product allow users to create smaller executables by dynamic allocation of arrays, write easily understood code, and improve program structure. New porting features support moving mainframe code to and from PCs. The system includes an editor, a debugger, a profiler, the SLR linker, a library manager, Opus Make, and video graphics libraries. F77L Version 5.0 is $595; upgrades start at $150.

Lahey Computer Systems, P.O. Box 6091, Incline Village, NV 89450, (800) 548-4778 or (702) 831-2500.

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PAGED MEMORY MANAGER

The Paged Memory Manager (PMM) from **Emerging Technology Consultants** is a heap management system to improve the performance of Windows and OS/2 PM applications. PMM saves time and reduces the overhead incurred by function calls to allocate or lock memory. It allocates, locks, and unlocks fixed-size "pages" transparently and manages the sub-allocation of memory within those pages. Features include multiple and heap-level locking, memory grouping, and debugging and statistics functions. PMM sells for $295 for the OS/2 or Windows version, or $495 for both. Source code licenses are available for $2,500.

Emerging Technology Consultants, Inc., 3405 Penrose Place, Boulder, CO 80301, (303) 447-9495.

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OPTLINK/COMPRESS 3.0

The OPTLINK/Compress 3.0 linker, from **SLR Systems,** provides compressed, single-level overlays. It produces self-extract-to-run EXE files that are up to 50% smaller than /EXEPACK. The embedded decompression routine runs automatically at file execution. OPTLINK/Compress 3.0 can compress more than 8,000 overlays. It allows indirect calls, EMS/XMS caching, overlays to a separate file, calls from overlay to overlay, large- and small-model overlays, and automatic allocation of libraries. OPTLINK/Compress 3.0 is $350; upgrades are $75.

SLR Systems, Inc., 1622 North Main Street, Butler, PA 16001, (412) 282-0864.

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NDPWIN AND NDPWIN-SDK

MicroWay's NDPWIN Windows 3 extender provides 32-bit support for the Windows 3 platform on the company's protected-mode 386 compilers for Fortran, C, C++, and Pascal. NDPWIN implements character- and graphics-based I/O, allowing users to create or run a 32-bit character-based application in a window or create an application that calls the Windows API. NDPWIN supports DOS and Unix features that are not available in Windows 3. The NDPWIN-SDK provides 32-bit access to the Windows GUI. The NDP compilers are priced at $895 each; NDPWIN-SDK is $1495.

MicroWay, P.O. Box 79, Kingston, MA 02364, (508) 746-7341.

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PERSONAL MEASURE V. 1.55

Spirit of Performance, Inc., has released Personal Measure Version 1.55. Personal Measure, which is compatible with MS-DOS 5, monitors the performance of PC hardware and software, pinpoints processing bottlenecks, and helps users tune overall system performance. The product, which is compatible with

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real, standard, and enhanced modes of Windows 3, also shows how network resources are used by programs. The TSR program that collects hardware and software performance data occupies less than 9K of memory. Personal Measure 1.55 is $125; upgrades are $50 for releases before Version 1.5, or $25 for later releases.

Spirit of Performance, Inc., 73 Westcott Road, Harvard, MA 01451, (508) 456-3889.

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QNX 4.0

Quantum Software has released QNX 4.0, an IEEE POSIX-compliant OS based on microkernel technology. The microkernel handles server tasks such as file handling, device I/O, and network management separately from the kernel, which executes scheduling tasks and coordinates message passing. QNX is a Unix-like OS for Intel-based PCs. QNX 4.0 is $795.

Quantum Software Systems Ltd., 175 Terrence Matthews Crescent, Kanata, Ontario, Canada K2M 1W8, (613) 591-0931.

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SMALLTALK/V WINDOWS 1.1

Digitalk's Smalltalk/V Windows Release 1.1 combines the company's object-oriented programming environment with Microsoft Windows 3. Smalltalk/V Windows includes source code browsers, inspectors, and push-button debuggers, as well as interfaces to DDE and DLLs. No runtime royalties are charged. Smalltalk/V Windows Release 1.1 is $499.95; upgrades are $25.

Digitalk, Inc., 9841 Airport Blvd., Los Angeles, CA 90045, (213) 645-1082.

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TOPAZ VERSION 3.0

Software Science has released the source code to its Topaz version 3.0 database management software. Topaz allows users to write relational database applications with standard dBASE file and syntax using Turbo Pascal or QuickPascal. The product supports full-screen editing, dBASE DBF files, indexing, report generation, a memo and text editor, search capabilities, print spooling, and pick and tag lists. With an executed license agreement, source code for Topaz Version 3.0 is $499. Registered Topaze owners can buy the source for $399.

Software Science Inc., 100 Valley Drive, Brisbane, CA 94005-1350, (415) 467-7077.

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WIN++

Win++, by **Blaise Computing Inc.**, is a Windows class library designed specifically for use with Borland C++. Win++'s extensive class libraries provide a foundation for Windows applications. Most of the classes provide a simplified, high-level C++ interface to Windows, and others can be used for representing internal data structures and integrating data into applications. Win++ provides a class for all common types of display objects in Windows that are accessed by handles, and it supports the construction of DLLs. Win++ costs $249, including source code.

Blaise Computing Inc., 819 Bancroft Way, Berkeley, CA 94710, (415) 540-5441.

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ASYNC PROFESSIONAL

TurboPower Software has released Async Professional, an object-oriented tool library to ease development of asynchronous communications applications in Turbo Pascal. Using a layered architecture, Async Professional provides both object-oriented and traditional procedural interfaces. All standard file transfer protocols are supported. Async also features hardware flexibility and debugging tools. Async Professional is $139.

TurboPower Software, P.O. Box 49009, Colorado Springs, CO 80949-9009, (800) 333-4160.

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GUI_MASTER

GUI_Master from **Vleermuis Software Research** is a program constructor for C++. This object-oriented toolkit allows faster development of event-driven, window-based programs in the OS/2 PM and MS Windows environments. Both versions are available for the Zortech and Glockenspeil C++ compilers; the MS Windows version for Borland's C++ compiler is in beta-test. GUI_Master has three parts: the Interface Builder, the Browser, and the Class Tree (which has 85 GUI interface classes). GUI_Master OS/2 PM costs $495, and the price for the MS Windows version is $545.

Vleermuis Software Research, P.O. Box 2584, 3500 GN Utrect, The Netherlands, 31/30 31 04 26 (fax).

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WATCOM C/386 FOR WINDOWS

Watcom's new C/386 for Windows enables the development of 32-bit Windows 3 GUI applications. It has an interactive debugger and is ideal for porting 32-bit Unix and Mac applications to Windows 3. C/386 is compatible with Microsoft library and source. It is selling for $2,250, or $1,295 for upgrades that allow 32-bit applications in DOS or Windows.

Watcom, 415 Phillip Street, Waterloo, Ontario, Canada N2L 3X2, (800) 265-4555.

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VISUAL COMPARE

Visual Compare from **Whitney Software, Inc.**, lets you see the differences between two program source files in a full-screen display. Differences between files can be selectively discarded. Visual Compare's scrollable display highlights common, deleted, and inserted lines. The price is $30 for DOS or OS/2, or $45 for DOS and OS/2.

Whitney Software, Inc., P.O. Box 4999, Walnut Creek, CA 94596, (415) 933-9019.

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C-DEBUG

Softran Corporation is offering C-Debug, a preprocessor for C language programs. C-Debug works with any C compiler and hardware or operating system. It alerts users to data corruptions in memory areas. Errors are located and described, minimizing guesswork. C-Debug for DOS is $249, for Novell $349; prices for other operating systems are available from Softran.

Softran Corporation, One Naperville Plaza, Naperville, IL 60563, (800) 462-3932.

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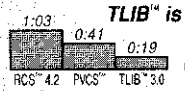

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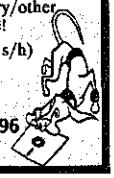

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See feature article in March 1991 Microsoft Systems Journal (pg 49)

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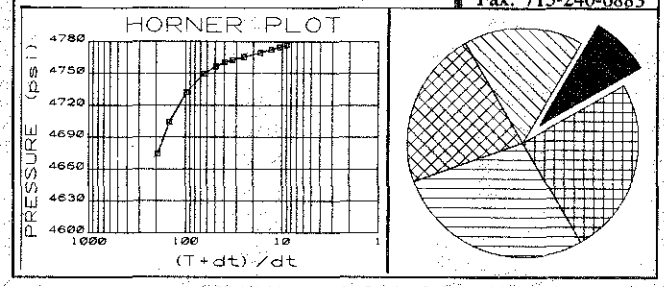

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Playing for keeps

By Hal W. Hardenbergh

Successful companies, like successful people, tend to gather enemies. It's no accident that Microsoft and Intel are currently being investigated for allegedly unfair business practices (one assumes that Compaq and Lotus are next in line).

Back around 1970, some officials of the U.S. Department of Justice decided that IBM was unfairly monopolizing the U.S. computer market. For 10 years, Justice tried to break up IBM. About the time Reagan was elected, somebody finally figured out that the United States needed a strong computer company in the international, not the national, market. And so the suit was quietly dropped.

IBM was only the first company Justice was trying to break up. The second company on their list was General Motors, and GM was running scared. Unlike IBM, whose sales were almost all based on the 360/370 architecture, GM would have been simple to break up: just break out each division (such as Chevrolet) as a company. In 1970, each GM division was making its own engines, transmissions, and so forth.

GM decided on a defensive reorganization. It spent billions and billions of dollars to remake the company. It created one engine division that made engines for all of GM's cars. It created one transmission division. The reorganization apparently fulfilled its objective, because Justice never did attempt to break up GM.

An unfortunate side effect of the reorganization was that all GM cars began to look pretty much alike, for the very good reason that they *were* alike. Why buy an expensive Cadillac when it's just a Chevy with different chrome trim? That, along with the 1974 oil crisis, accomplished Justice's goal of reducing GM's domination of the U.S. market, with no court proceeding necessary. It also started our "balance of trade" problem, because it gave people a reason besides fuel economy to buy a foreign, not a GM, car.

The point is that GM's reorganization was a protective move to defend itself from our legal system. Almost 20 years later, Intel is making similar protective moves, for the same reason. This is a wise decision on Intel's part; our legal system is even more arbitrary and capricious these days than it was when Justice made IBM spend billions of dollars to defend itself, only to abandon the antitrust lawsuit in the end.

ILLUSTRATION BY JIM CARPENTER

In November 1981 there was a wedding between Intel and AMD. IBM, which wanted a second source for the 8088 used in its PC, held the shotgun. This "wedding" was a contractual arrangement scheduled to run for 10 years; it will expire shortly after you read this. Like many weddings these days, this one didn't "take." The divorce proceedings are not just unseemly but downright vicious.

The contract called for AMD to get rights to Intel microprocessors in exchange for AMD products of equal technological (but not necessarily commercial) value. At the time the contract was signed, a microprocessor could be developed for about $100,000. These days, the cost is more than 100 million dollars. Intel did not believe that AMD upheld its end of the contract, so it withheld the 386 design from AMD. Obviously, AMD disagrees. If this contractual dispute were to be fought in regular civil court, the lawsuit would be in progress into the next century. Intel and AMD, to their credit, decided that arbitration was the sensible way to go. So they found a retired judge who was agreeable to both parties to serve as the arbitrator (aka rent-a-judge), and the three parties negotiated a contract. *Another* contract, that is.

This three-party contract specifically limited the amount of dollar damages that the arbitrator could award to either party. One of the first things the arbitrator did—I am not making this up—was to *file suit in civil court to increase by an order of magnitude the amount of monetary damages he was allowed to award!* How could he do this? This is a contract dispute; the three-way contract was between Intel and AMD on the one hand, and the arbitrator on the other!

Yet the purpose of the arbitration was to stay out of civil court! Yikes! Are you beginning to see why some folks think our legal system is out of control? (An aside: most people think justice is what you're supposed to get in court. No, that's what you're supposed to get in *criminal* court. In civil court what you're supposed to get is law. If you're one of the complainants, you won't like the law. Ask any veteran of a messy divorce proceeding.)

The arbitrator has also refused to rule out the possibility of awarding Intel microprocessor designs to AMD, even without the contractually required even-technology exchange. *That's* why you're seeing so many different versions of the x86 architecture in Intel's product line: the supposition is that the arbitrator surely wouldn't award Intel's entire portfolio to AMD.

So the 50-MHz 486 is not just a shrunk 486. In addition to moving from 1 micron to 0.8 microns, the chip was actually redesigned, using three layers of metallization rather than two. I count five distinct products in Intel's x86 line now: the 386DX, the 386SX, the 386SL, the standard 486, and the new 50-MHz 486 (the 486SX and 487, for now, are pin-out variants of the standard 486).

All of us have an interest in the continuing development of the x86 product line. No company, not even Intel, can afford to spend hundreds of millions of dollars for future versions of the x86 architecture only to be forced to give its product to a competitor. AMD has lots of fans—perhaps including you?—in its corner. Be careful what you wish for; you might get it.

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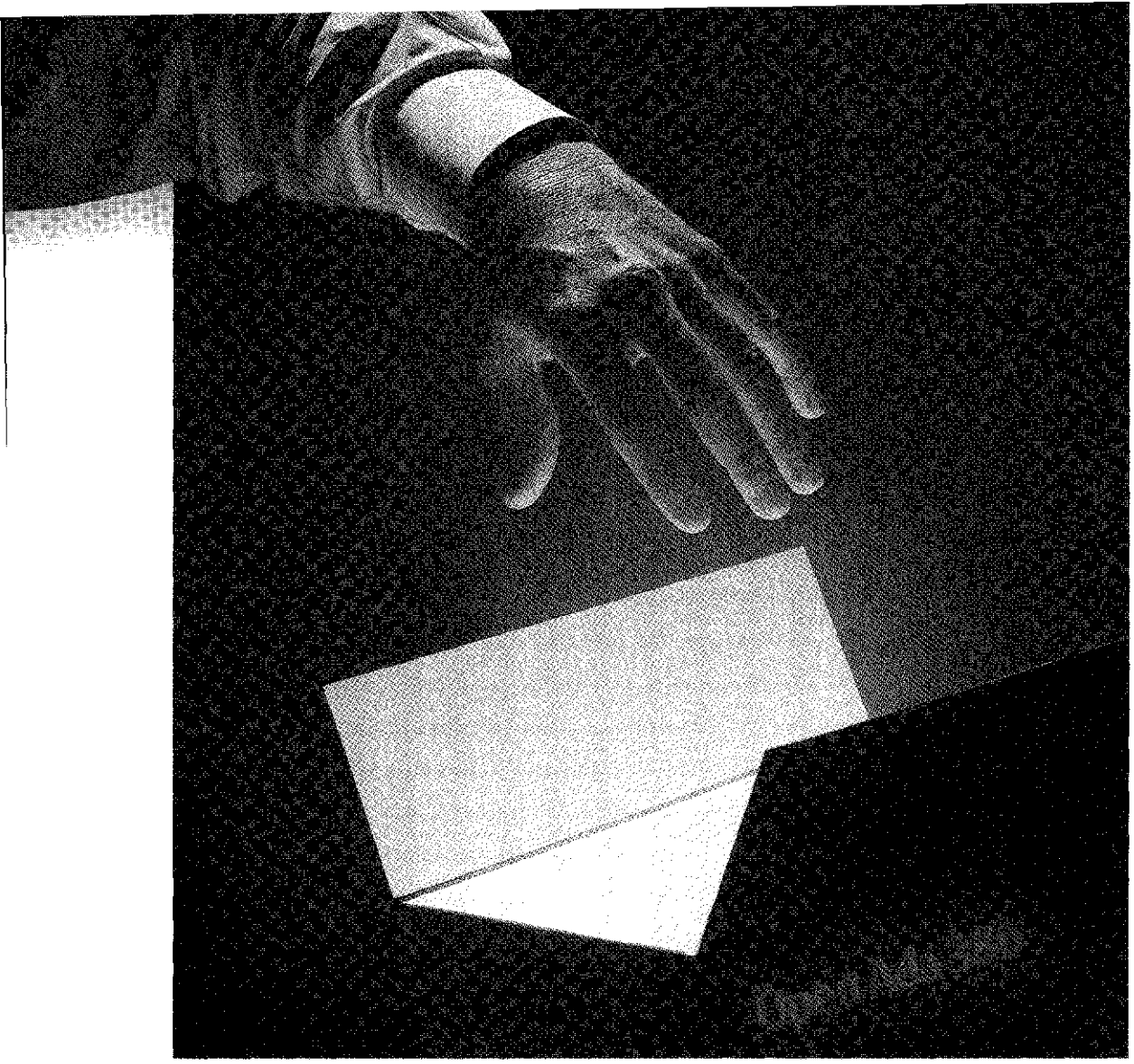

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